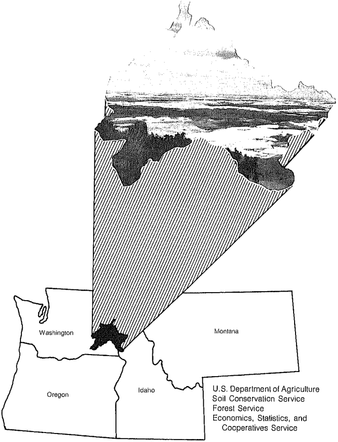
PALOUSE COOPERATIVE RIVER BASIN STUDY



U.S. Department of Agriculture
Soil Conservation Service
Forest Service
Economics, Statistics, and
Cooperatives Service

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PREFACE

Preface

This report assesses impacts of soil erosion on land and water quality. Physical, economic, and social impacts of sediment reduction are evaluated.

The major study thrust is to provide basic data needed to develop sediment reduction plans and to implement Section 208 of Public Law 92-500. The study is oriented to the agricultural elements of non-point sources of sediments and other pollutants. Range and forest areas are evaluated and discussed in less detail because soil losses on these lands are much less significant. Basin forests are located primarily in the State of Idaho. Therefore, forestry data on the Idaho-Palouse is shown in a separate chapter to better meet Idaho's water quality data needs.

The United States Department of Agriculture agreed to participate with the State of Washington in this special study in 1975. The study is under authority and provisions of Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress 68 Stat. 666, as amended). Cooperating in the study were the U.S. Soil Conservation Service (SCS), U.S. Forest Service (FS), the Economics, Statistics and Cooperatives Service (ESCS), and the Department of Ecology (DOE) representing the State of Washington.

The following summary provides a brief overview of report findings.

Summary

The Palouse River Basin Study has shown that soil erosion is a continuous and serious problem on non-irrigated cropland areas in eastern Washington. The study has shown that the problem can be solved. It has also shown what kinds of conservation practices can be most effective in solving the problems and what economic and other impacts will result from their application.

Study results show that:

- over 90 percent of the basin's erosion results from sheet and rill erosion on cropland
- 360 tons of soil has been lost from every cropland acre in the basin since 1939
- it is projected that the basin will continue to lose 17 million tons of soil, an average of 14 tons per acre per year, from all cropland areas
- average annual soil erosion rates from the central portion of the basin are 20 tons per acre
- annual erosion rates in the western (12-15" precipitation zone) and eastern (over 18" precipitation zone) average over 12 tons per acre
- present average wheat yields of 50 bushels per acre could be an estimated 20 percent higher if erosion in past years had been controlled
- all of the original topsoil has been lost from 10 percent of the land
- 3 million tons of sediment is carried out of the basin in and with runoff water each year
- over 50 percent of the erosion in the basin comes from the steeper land which accounts for only 25 percent of the cropland
- summer fallow is a major cause of soil erosion
- minimum tillage can reduce erosion rates by 35 percent
- field stripcropping can reduce erosion by 15 to 28 percent
- terraces can reduce erosion rates by 8 to 13 percent
- erosion rates can be reduced by 40 to 60 percent without adversely affecting farm income, additional reduction becomes increasingly costly
- erosion can be reduced by as much as 80 percent but at a cost of $29 million
- retirement of steep, highly erosive cropland areas to grass can significantly improve wildlife habitat and increase wildlife populations.

Since the basin was first farmed in the late 1800's, soil erosion resulting from runoff water has been a continuous and increasing problem. Most of the precipitation, both rain and snow, occurs during winter months. Most erosion occurs in the winter and spring. Amounts of erosion are influenced by the steep topography of much of the cropland area; highly erodable loess soils; kinds of farming systems used; temperature; and rainfall intensity patterns.

Study results also show that erosion rates on rangeland areas are projected to average less than one ton per acre per year. Forested areas in the mountainous eastern Idaho-Palouse and in the northern Washington basin average less the one-half ton per acre per year.

Gully erosion, though serious when it occurs, accounts for only a minor part of soil eroded from the basin annually. Stream channel erosion is most serious in mountain forest areas. It accounts for 50 percent of the erosion from these areas. It amounts to less than 1 percent of total basin erosion, however.

Studies conducted since 1939 show erosion caused by runoff water on cropland is a serious environmental problem. During the past 39 years nearly 360 tons of soil has been lost from every acre—an average of over 9 tons per acre per year.

These high soil erosion rates are expected to increase. Erosion rates were projected using the Universal Soil Loss Equation (USLE), newly developed for eastern Washington. Annual erosion rates are projected to be 17 million tons per year—an overall average of 14 tons per acre—unless farming systems change.

Erosion rates on portions of fields are much higher than overall averages. Rates of 20 to 30 tons are common and 100 to 200 tons per acre losses occur frequently on some steep slopes. Erosion rates on cropland are usually less in the lower precipitation zones of the western basin (13 tons per acre per year) and in the high precipitation zones of the eastern basin (12 tons per acre per year). Highest rates have consistently been measured in the intermediate 15 to 18 inch precipitation zone (20 tons per acre per year). They are highest in that zone because of extremely steep topography; complexity of

slopes; farming systems used and climatic conditions.

High erosion rates cause severe losses. All of the original topsoil has been lost from 10 percent of the cropland in the basin. One-fourth to three-fourths of the top soil has been lost from another sixty percent of the cultivated area. This loss has left the land less productive. Eroded soil causes other problems, too. Silt smothers crops in bottomland areas. Nearly a million dollars is spent each year cleaning silt from highway ditches. Stream channels, waterways and drainage ditches fill with silt, increasing flood problems. At Palouse Falls, near the mouth of the Palouse River, half a million acre feet of water flows from the basin each year. It is a beautiful waterfall but the water in late winter and spring rarely flows pure and clear. Instead, it runs thick and brown with approximately 3 million tons of precious topsoil from some of the most valuable farmland in the Nation. From there sediment goes on to fill downstream hydroelectric reservoirs, destroy fish habitat, ruin recreation areas and pollute the waters, making them unfit for other uses.

The study shows that the problems of soil erosion and water pollution from sediments can be solved. The farmer can do little to change the weather, kind of soil, or steepness of the land he farms, but he can change the way he farms the land. If farmers are going to reduce erosion they need to do such things as reduce acreages of summer fallow, till the soil less, retire the steepest, most erosive areas from cultivation, change cropping systems, divide long slopes with two or more crops and install terraces on long, gentle slopes.

The use of summerfallow, especially in the higher rainfall portions of the central and eastern basin, is a major contributor to soil erosion. When fields are summerfallowed, uncropped land is clean tilled during the summer to control weeds and store moisture for growth of the next year's crop. Erosion rates on summerfallow fields average 25 to 30 percent higher than non-fallow fields.

Fields that are excessively cultivated also erode more. Use of minimum tillage methods for seedbed preparation on annually cropped land or stubble mulch on summerfallow fields can reduce erosion rates by 35 percent.

More than 50 percent of the erosion comes from 25 percent of the steeper cropland. Retirement from cultivation of part or all of this land would reduce erosion and sediment significantly.

Divided slope farming and installation of field stripcropping systems can reduce erosion rates by 15 to 28 percent. Terraces can reduce erosion rates another 8 to 13 percent.

In the study, effects of applying combinations of these conservation practices with different cropping systems were evaluated. A series of branching charts are displayed to show these combined effects. The charts show that erosion rates on Class II and III lands can be reduced to less than 5 tons per acre if the right combinations are used. Erosion rates on Class IV and VI lands can also be reduced significantly. However, erosion rates on Class VI lands will remain high and can best be controlled by retirement from cultivation.

As various levels of conservation treatment are applied to the land, the economy of the basin will be affected. Erosion rates can be reduced by 40 percent in the low and high precipitation zone and 60 percent in the intermediate precipitation zone without adversely affecting farm income.

Erosion rates can be reduced by 80 percent through application of maximum levels of conservation practices and retirement of 35,000 acres of Class IV and VI land. The benefits of achieving this erosion reduction level could be attained, but at a cost in excess of $29 million in reduced productivity and increased operating costs.

As erosion rates are reduced through conservation practice application, sediments delivered to stream systems will decrease accordingly. Wildlife habitat values increase only slightly as more conservation is applied to the land. However, when Class IV and VI land is retired from cultivation, habitat values increase by 4 to 18 percent. Fuel and fertilizer use will increase if less land is summerfallowed and instead planted to crops each year. As maximum erosion reduction levels are achieved through retirement of the steeper farmland, fuel and fertilizer use will decline significantly.

A specific combination of alternatives has not been selected in this study. This decision has been left for user groups. Results of the study have been provided to user groups as it was developed. Its primary benefit was to people in eastern Washington as they have developed County water quality plans and selected best management practices for these plans. The information will continue to be useful as those plans are implemented in carrying out the mandates of PL 92-500 (Section 208)—the Clean Water Act of 1972. It will be

useful as a guide to farmers in selecting conservation practices. It is also a useful tool to those who provide technical assistance to farmers and those who must make policy decisions dealing with soil erosion and sediment problems.

Much more conservation should be applied in the basin as County water quality plans are implemented. The series of Erosion Reduction Plans presented are practical alternatives that are being used by some farmers at this time. They are alternatives that user groups, including Conservation District Supervisors, County Water Quality Committees and conservation and research technicians, asked the study team to evaluate.

Since significant erosion reduction can be achieved without adverse economic impacts, implementation should be easier. Farmers will have to change farming systems and learn how to farm differently. This is not easy and will take time. If very high levels of erosion reduction are to be achieved, large capital outlays and reduced incomes will result. Someone will have to pay this cost, either the farmer or the taxpayer or both.

Legislative changes may be needed before adequate conservation can be achieved. Procedures for implementation of the Water Quality Act have not as yet been fully resolved. Aspects of current farm programs encourage use of summerfallow while little encouragement is provided for retirement of the most erosive acres from production. Cost-share programs for conservation practices need to be evaluated. Improved methods to motivate people to make needed changes in farming practices need to be devised.

Since 1934 nearly three-fourths of a ton of soil has been lost for every bushel of wheat produced in the basin. There is a plentiful supply of soil in the basin but it is not inexhaustable. Some have come to regard it as only an immediate source of wealth. There are many others, however, who realize that it is truly a priceless heritage belonging as much to our children's children as to us. It is a heritage that can and must be saved for those future generations.

BASIN DESCRIPTION

Description Of The Basin

History

The Palouse Basin has been inhabited by human beings perhaps as long as 10,000 years, according to discoveries at the Marmes Rock Shelter near the mouth of the Palouse River. (a) The river was named for the tribe of Indians who lived along its lower reaches when the white people arrived on the scene. Several tribes used portions of the basin, but only the Palouse lived there the year round. The latter lived along the lower reaches of the Palouse River between the Palouse Falls and the Snake River.

Indians, never numerous (b), made their living from the land and the streams. Food limited expansion of their tribes. Fish was a main staple, but some deer, elk, rabbits, and bears were killed for meat and hides. There were no buffalo in the basin and the Indians trekked eastward over the Bitterroot Mountains in search of them to augment winter food reserves.

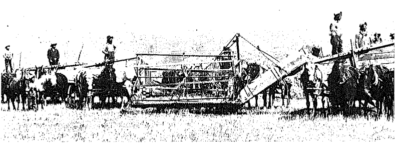
The Lewis and Clark Expedition is the first known overland exploration by whites this far west—as early as 1805. David Thompson, a geographer and trader for the English-owned Northwest Company, was the first white man reported to have crossed the basin, in August 1811. A year later, a Pacific Fur Company party traced a similar route, and the ever-increasing stream of "whites" began.

Fur traders passed through the basin. They headquartered at Spokane House to the north; Lewiston, in the southeast; and Walla Walla, to the southwest. Little trapping was done, however, except in the Moscow Mountains of the upper basin.

Missionaries came in the 1830's and '40's; military units in the 1850's and early 1860's—first as explorers, and later to keep the peace. By 1860, gold was discovered in the rich placers of the Clearwater River, the Coeur d'Alenes and near present-day Colville. A flood of prospectors and miners poured through the Palouse, many of them lawless elements of society who did not care about Indian culture or even Indian life. Conflicts increased, first by words and then by weapons.

As whites continued to pour westward, better transportation routes were developed; treaties were made and later broken, and Indians began losing their rights to desirable areas.

In 1853, Washington was made a Territory. Territorial Governor Isaac Stevens and the U.S. Government pressured Indians to relinquish title to their lands. Many battles broke out. (c) Indians were finally given reservation lands in exchange for rich, productive lands they had once claimed.



Horses and determined pioneers broke trail for present day agriculture in the Palouse.

In 1863, George Pangburn settled on lower Union Flat Creek, planted a few fruit trees, and began raising livestock. By 1869, several small settlements sprang up. The first trickle of settlers became a tide during the next two decades. Colfax and Palouse City were the earliest communities to reach significant size.

The government surveyed most of the land in the Palouse River Basin during the period 1872-77. (d) Some land was settled before this, but the surveys provided means for legal acquisition. Virtually all arable land in the basin was settled from 1870-1885. (e)

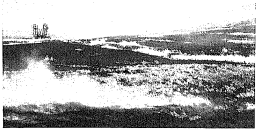
Early settlers raised livestock and cultivated only enough bottom land to produce gardens and grain for family needs. Markets for large crops of grain was the limiting factor. The Palouse grassland-livestock era ended with railroad construction in the early 1880's. Almost overnight "horsepower" cultivation of the Palouse hills changed lush grassland to black cropland. Major crops in those first years of dryland farming were grains, sugar beets and thousands of acres of orchards.

Until railroads brought new and better equipment west from factories in the east, grain cropping was quite primitive. In those times, soils on the Palouse hills were exceptionally fertile, with many fields yielding upward of 70 bushels of wheat per acre. Forty years later, the average yield in Whitman County was only 26.4 bushels per acre.

There were many problems over the years—some disastrous. Pests, mainly grasshoppers and ground squirrels, were the first. (f) In 1893, many farmers were unable to harvest a spear of grain because of unusually wet fall weather. (g) A national money panic followed. Floods took a severe toll in 1910; grain diseases reduced yields just prior to World War I, and by the early 1940's weeds began invading fields. (h)

The most widespread and critical problem of all was scarcely noticed; erosion of soil from Palouse hills. Until people cultivated and pulverized the soil with farm equipment, there was little erosion. Summerfallow became a well established practice on most Palouse farms by the early 1890's. Washington and Idaho State Experiment Stations began to recognize erosion as a problem. (i)

A chain reaction of changes and events—some good and some bad for the land—has taken place in the last five or six decades. Introduction of field peas for areas of high precipitation made annual cropping possible, thereby reducing the erosion hazard. (j) Then, the newer, horse-drawn combine harvesters created the problem of excess straw after harvest. The only recourse for the farmer was to set fire to the stubble after harvest. Eighty to 95 percent of the residue went up in smoke and nothing was returned to the soil as humus. (k)

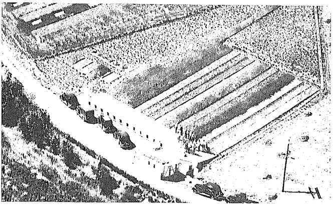


Stubble burning leaves a bare unprotected soil surface.

When crawler tractors replaced the horse, steeper lands previously used for hay and pasture were converted to grain. Greater power moved equipment faster, pulverized soil even more and caused more down-slope movement. Now farmers were able to go up and down hills instead of working on the contours, as in the days of horse-drawn equipment.

Since pastures were no longer needed for horses, fences and fence rows were removed, along with many early timber plantings. Habitat for wildlife was gradually disappearing.

Concerned about the erosion problem, Congress in 1929 authorized ten regional experiment stations throughout the nation to study the causes and cures of soil erosion, of them one at Pullman, on Washington State College land.



Erosion problems were studied and cures were recommended.

By 1933, the new Soil Erosion Service and Civilian Conservation Corps were working closely on natural resource problems. The Soil Conservation Service was established April 7, 1935 as a permanent agency in the U.S. Department of Agriculture. The new agency had broad authority to carry out erosion and flood control work on public and private lands.

A model conservation district law was presented to governors of the 48 states to further soil and water conservation efforts by local people. Washington and Idaho acted quickly and passed the enabling legislation by 1939. The Latah district in Idaho and North Palouse of Washington were the first to organize in the Northwest. Erosion control programs were well on their way when World War II began. During the war, many grasslands were plowed out and planted to grain or peas as part of the "Food For Freedom" program. This was a severe setback for erosion control progress.

In the post-war period, commercial fertilizers replaced the practice of growing and turning under legumes for fertilizer. Chemical sprays, improved crop varieties, huge grain surpluses and a return to summerfallow under the wheat allotment program also set back erosion control programs.

The Soil Erosion Service made a reconnaissance survey to determine the extent of soil erosion in the area. Demonstration projects were established to demonstrate erosion control. Men from the CCC camps carried out cooperative projects between farmers and the government. Among the accomplishments were numerous grass and tree plantings, construction of grassed waterways and gully control structures and improved farm management systems. The Soil Conservation Service has continued to carry out activities started by these early efforts. Major SCS activities have included technical assistance to basin farmers and ranchers in planning and applying conservation practices on the land.

Geological Development[1]

Geological processes formed the Palouse River Basin millions of years ago and basically determined what the area is like today. Forces deep within buckled the earth's crust. Upward shifting of giant slabs of granite were forced even higher. Thus began the geological uplift, volcanic activity, erosion and flooding that created the Palouse. Remnants of this massive uplift are still visible in the mountains and buttes of the eastern portion of the basin.

Following the mountain uplift, volcanoes erupted about 10-30 million years ago, spewing forth a series of lava flows—sometimes at short intervals; but during other periods, tens of thousands of years intervened. Early flows filled the valleys. Subsequently, the flows covered most of the high hills and eventually formed a solid sea of basalt—more than 10,000 feet thick in places. Many individual flows, more than 75 feet thick, extended more than a 100 miles. A few hills protruded—island-like—through the basalt around the edges of the lava field. The most prominent of these hills is Steptoe Butte near Colfax, Washington. This term now is used by geologists worldwide to identify any island of older rock, surrounded by lava: a "steptoe".

Then the dust storms started. Widespread wind erosion occurred in eastern Washington and Oregon. The magnitude can hardly be imagined. Windblown soils drifted over and filtered down to cover the lava field with deposits as thick as 200 feet.

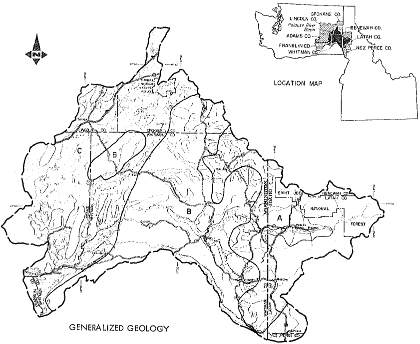
Prevailing southwest winds left loessal deposits in dune-like shapes. These hills have gentle south and west facing slopes. Many north and east slopes were left with steep and short slopes. All but the highest buttes and mountains of the eastern basin were buried by these deposits.

This, then, was the Palouse of about 100,000 years ago—a thick, tilted saucer of basalt, warped in places into ridges, and completely overlain by a frosting of loess. According to geologists, the view from the top of the Steptoe Butte would have revealed peaceful, rolling grasslands. To the east, the Bitterroot Mountains and to the west, the Cascade Mountains were distant hazy blue backdrops of peace and quiet. This tranquil scene, however, was the setting for a catastrophe.

Movement and melting of glaciers and great icefields in southern British Columbia created mammoth ice dams in the valleys, forming

Steptoe Butte—a remnant of the past.

lakes. When the ice dams burst, the released water swept away the loess material like a giant broom. Three giant rivers raced across eastern Washington. Soil was scoured down to the lava field, leaving behind a significantly different landscape that has become known as the channeled scablands—which exist nowhere else in the world. Here and there a loess island still stands above the surrounding terrain as a relic of the past. The easternmost river carved the widest channel: The Cheney-Palouse Tract which is the channeled scabland area of the western portion of Palouse Basin. Elsewhere, however, the deep loess has remained to become the fertile soil of the Palouse. Thus, was this vast, beautiful and highly productive land called the Palouse formed in geologic history.



GENERALIZED GEOLOGY

Loess of late Pliocene, Pleistocene, and Holocene age
Mostly silt and clay

Basalt of Columbia River Group of Miocene and Pliocene age
Exposed primarily in channels eroded by glacial floods during Pleistocene time

Metamorphic and intrusive igneous rocks of pre-Tertiary age

Boundary between subareas

Subareas

A, eastern steptoes and foothills of Clearwater Mountains, of high local relief, with timber in higher areas.
B, central area, chiefly loessal hills of moderate local relief, with some timber in northern part.
C, channeled scablands, with some loess-mantled islands, little local relief, with timbered areas in northern part.

GENERALIZED GEOLOGY
PALOUSE RIVER BASIN
IDAHO AND WASHINGTON

JANUARY 1977

SCALE 1:1,000,000 — 5 0 5 10 MILES

Source:
Base map prepared by SCS, WTSC Carto. Unit from State Staff compilation.
Thematic detail prepared from USGS Generalized Geology Map.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

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Resources of the Basin

Water

Rivers and Streams

Through this unique landscape flows the Palouse River which originates in the Moscow Mountains of west-central Idaho's "Panhandle." The Palouse flows southwesterly toward a deep canyon of basalt and plunges over Palouse Falls near the confluence of the Palouse and Snake Rivers. Major tributaries are the North and South Fork of the Palouse River, Rebel Flat Creek, Rock Creek, Pine Creek, Union Flat Creek and Cow Creek.

The Palouse North Fork watershed drains 15 percent of the river basin and yields 41 percent of the runoff. Cow Creek watershed, which drains 20 percent of the area, yields 7 percent of the runoff water in the basin.

Palouse River Canyon

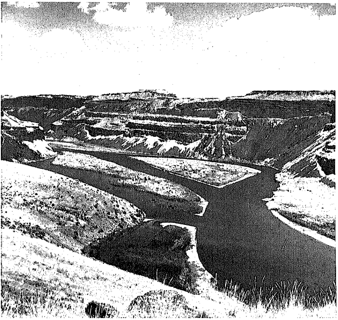


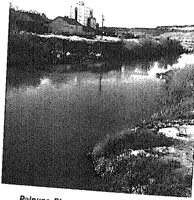
Table 1. Average Annual Water Yield From Sub Watersheds— Palouse River Basin

Sub-Watershed	Acres	Main Stem Length (Miles)	Avg. Annual Water Yield (Ac. Ft./Yr.)
S. Fork Palouse	187,220	34	77,000
N. Fork Palouse	316,910	54	188,000
Rebel Flat Creek	50,940	20	6,000
Cottonwood Creek	96,390	20	12,000
Pine Creek	197,400	48	44,000
Thorn Creek	42,970	14	8,000
Rock Creek	283,530	28	30,000
Cow Creek	427,820	38	33,000
Union Flat Creek	201,720	72	31,000
Palouse River Main Stem	309,070	70	26,000
Total Palouse River	2,113,970	398	455,000

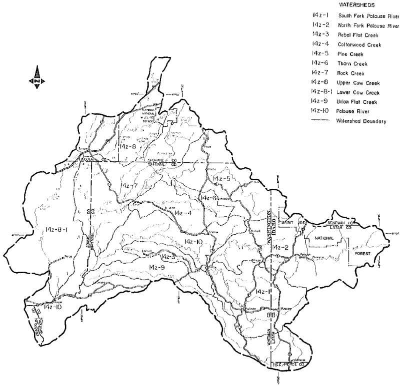
These streams drain a basin that begins at an elevation of 5,300 feet. Where the Palouse empties into the Snake River, the elevation is about 500 feet. Flows begin to decrease in May when mountain snows have melted and then steadily increase in late October when precipitation begins to build up again.

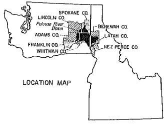
Extremes in mean annual discharge in cubic feet per second, measured at Hooper, Washington, vary from a low of 256 cfs in 1937 to an all-time high of 1410 cfs in 1974.

Agricultural use of water from the Palouse River and its tributaries is limited to a few sprinkler systems on land adjoining these streams, principally for supplemental irrigation of hay, pasture, and some small grains. Extreme fluctuations in flow rates, low summer flows, lack of adequate storage sites and extremely heavy siltation severely limit domestic use of Palouse River water. In the canyon rangeland areas, especially in the low-rainfall areas of the western basin, these streams are a valuable source of water for livestock. Except for three small ponds in Idaho, the river is free flowing.



Palouse River at Hooper, Washington





WATERSHEDS
PALOUSE RIVER BASIN
IDAHO AND WASHINGTON

JANUARY 1977

SCALE 1:1,000,000

Source:
Base map prepared by SCS, Portland Carto. Unit from State Staff compilation.
Thematic detail compiled by State Staff.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

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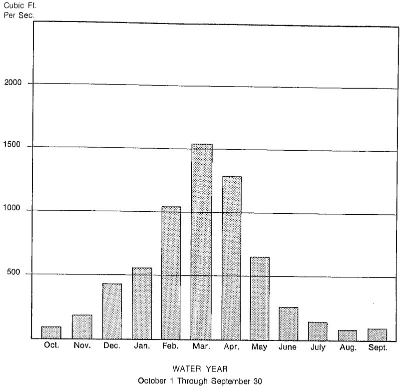
Figure 1 Average Monthly Streamflow—Palouse River Gaging Station 1929-1976, Hooper, Washington



Source: U.S. Geological Survey, Water Resource Data for Washington

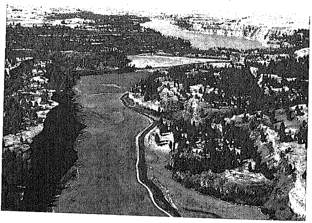
Lakes

The basin has 42 lakes that contain water throughout the year. In addition, there are numerous seasonal lakes and potholes that dry up during summer months. Most lakes are in the Cow Creek and Rock Creek watersheds. They were formed by flooding, carving and gouging of the landscape during early ice age and glaciation periods.

Many of these lakes have no outlets and are essentially large water filled depressions with basalt or lava rock bottoms.

Surface areas of the lakes range from under 20 acres to the 2,147 acres of Rock Lake. Total water surface of lakes in the basin is more than 8,500 acres—13 square miles.

Rock Lake in the channel scablands of western basin.



Ground Water

Basalt, the primary aquifer unit, occurs at varying depths throughout most of the basin. Water is stored in and moves through this basalt.

Wells in the central and western basin yield from 500 to 2,000 gallons of water per minute. Fine-grained sedimentary strata has reduced permeability of the basalt in most of the eastern basin where wells generally yield 500 gallons a minute or less. Even where ground water is available, the aquifer is often very deep and high lift pumps are required.

Since groundwater yields are so variable, determination of yield potential from individual wells can be obtained only through special investigation and testing. Costs of drilling and testing can be very high.

Most of the wells in the basin are now used for domestic and livestock water. Only a few wells produce sufficient water for irrigation purposes. Heavy municipal use of water at Moscow and Pullman has lowered water tables in that area.

Soils, Climate and Topography

There are many different soils in the basin. Topography and climate also differ within the area. Major differences in soils, climate and topography can be found as one travels through the basin from east to west.

Temperature is influenced by both continental and marine weather patterns. Maximum temperatures of 110 degrees F. have been recorded. Summers are hot, dry, and sunny. Conversely, winters are cold, with frequent periods of cloudy or foggy weather. A minimum temperature of 37 degrees below zero has been recorded. Lengthy cold periods are unusual. Frequent subfreezing temperatures often cause the top several inches of soil to freeze. Warm, moist air masses—called "chinooks"—move through the basin, resulting in rain on frozen soils. When this occurs, soil erosion is extensive and severe.

The frost-free period in these cultivated areas averages 150 days, compared to less than 100 days in the Moscow Mountains. The short growing season limits the types of crops that can be grown.

Prevailing winds from the southwest are generally moderate. High wind velocities of 1-2 days duration occur several times annually, primarily in April and October.

Soils have been grouped into 20 associations (see map, following page 14). Each of these associations designate a landscape with a distinctive proportional pattern of soils, usually one or more major soils, and at least one minor soil. Soil associations have been further incorporated into six major groups. These groups include associations with similar depth, parent material and positions.

In the extreme eastern basin, mountain peaks usually are clad with deep snow in winter and receive up to 46 inches of precipitation annually (preceding page 15). These mountains are generally covered with dense forests. Here, at elevations of 2,800 to 5,000 feet, **moderately deep soils have formed in weathered rocks on mountain uplands.** Topography of the area is steep, often rocky and extremely erosive when not protected by vegetative cover. These soils cover about 8 percent of the basin.

Deep soils formed in loess on uplands are located in foothills to these mountains. Average annual precipitation ranges from 22 to 35 inches. Although forested, many parts of the area have been cleared for intensive nonirrigated crop production; some at higher elevations are still used for forest production. These soils cover approximately 4 percent of the basin.

Near the Washington-Idaho border are very **deep to moderately deep soils formed in loess and rock fragments on buttes** that are a permanent feature of the landscape. This group occupies scattered buttes with elevations ranging from 2,500 to 4,000 feet. The buttes rise 1,000 feet or more above the surrounding landscape. Sideslopes of the buttes are steep. Most soils in the group are well-drained silt loams. Lands with milder slopes are used for dryland farming while steeper areas are used for range, forest and wildlife. Average annual precipitation ranges from 21-23 inches. This group covers about 2 percent of the basin.

Surrounding these buttes and extending westward to the channeled scabland areas are **very deep soils formed in loess on uplands.**

This group occupies upland hills and ridges ranging from 1,200 to 3,000 feet. These soils cover 44 percent of the basin and are the base for most of the cropland.

Soils in this group have many similarities and some differences. Most differences relate to the low (12 inches) average annual precipitation in the western basin and high (23 inches) in the eastern basin. Precipitation differences influence types of vegetation and conditions under which the soils were developed. Soils in the higher annual rainfall areas were developed with more lush vegetation and are for the most part darker because of high humus content.

Loess hills in the eastern basin generally have more gentle slopes than in the central basin, but are still steep. In the central basin, hills are much more irregularly shaped and steeper. The north side of the hills often have amphitheater-like enclosures. Many hills in the central basin have narrow tops and are more irregular than in other areas of the basin. Primary topography is a series of roughly parallel hills.

Most drainage patterns in this group are nearly parallel, with U-shaped draws. Some soils in the eastern portion of the area are not well-drained and have slow permeability.

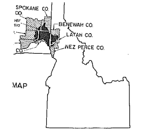
Hills in the western basin are not as steep. Stream channels are more pronounced and often are gouged through loess to bedrock. There are some trees, primarily along stream

Transecting these deep loess soils are areas dominated by very deep soils formed in loess in valleys. This group occupies major drainageways in the basin, including the valley sideslopes. Soils are similar to those of the area the streams transect. In this group are bottom land soils and gentle sloping to very steep side slopes leading down to the flat bottom land. Soils in these areas encompass approximately 11 percent of the basin and are used for dryland farming, pasture, rangeland, forests and wildlife.

Bordering the western edge of the basin are very shallow to moderately deep soils formed in loess and glacial outwash in channeled scablands. Precipitation here varies from 12 inches annually in the southwest to 18 inches in the north. Soils are well-drained cobbly loams and silt loams underlain by basalt bedrock. Basalt bedrock and steep basalt cliffs are exposed randomly. Occasional loess islands, not removed by glacial outwash, also are found in this area.

There are many undrained basins and lakes of varying sizes in the northern portion of the area. Because of shallow soils and rocks, most of the area is used for rangeland, forest production and wildlife. Vegetation consists of grasses, sagebrush and various forbs. Scattered stands of ponderosa pine, aspen and Douglas fir occur in the northern portion of this association where precipitation is sufficient. This soil group encompasses approximately 31 percent of the basin.

Stream channels are deeply etched into the basalt, with canyon walls reflecting these deep, sharp cuts. Winding southward, through the canyons, the Palouse River makes a final majestic plunge of 185 feet over Palouse Falls, near its confluence with the Snake River.



SOIL ASSOCIATIONS

AREAS DOMINATED BY VERY DEEP SOILS FORMED IN LOESS, ON UPLANDS

- 1 Walla Walla Association
- 2 Athena Association
- 3 Athena-Calouse Association
- 4 Palouse Association
- 5 Palouse-Staley Association
- 6 Palouse-Thatuna Association
- 7 Palouse-Thatuna-Naff Association
- 8 Bagdad Association
- 9 Ritzville-Willis Association

AREAS DOMINATED BY VERY DEEP SOILS FORMED IN LOESS; IN VALLEYS

- 10 Palouse-Athena Association

AREAS DOMINATED BY VERY SHALLOW TO MODERATELY DEEP SOILS FORMED IN LOESS AND GLACIAL OUTWASH; IN CHANNELED SCABLANDS

- 11 Anders-Benge-Kuhl Association
- 12 Bakeoven-Tucannon-Cheney Association
- 13 Stratford-Roloff-Starbuck Association

AREAS DOMINATED BY VERY DEEP TO MODERATELY DEEP SOILS FORMED IN LOESS AND IN COLLUVIUM AND RESIDUUM FROM METASEDIMENTS, ON BUTTES

- 14 Palouse-Thatuna-Tekoa Association

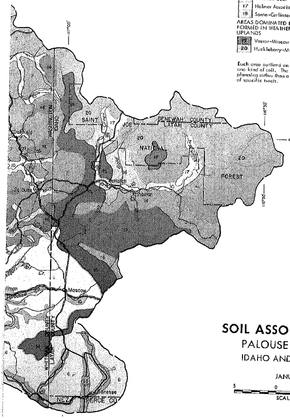
AREAS DOMINATED BY DEEP SOILS FORMED IN LOESS, ON UPLANDS

- 15 Larkin-Southwick Association
- 16 Freeman-Joel-Taney Association
- 17 Helmer Association
- 18 Santa-Carlinton-Helmer Association

AREAS DOMINATED BY MODERATELY DEEP SOILS FORMED IN WEATHERED ROCKS, ON MOUNTAIN UPLANDS

- 19 Vassar-Moscow-Grano Association
- 20 Huckleberry-Minaloosa-Xerolls Association

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



SOIL ASSOCIATION MAP

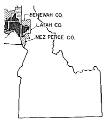
PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

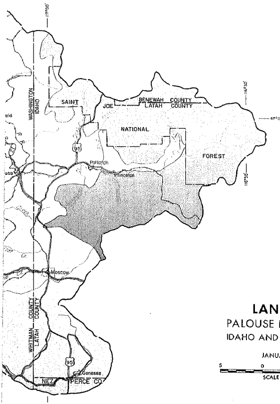
5 0 5 10 MILES

SCALE 1:500,000



LAND USE

- Cropland
- Rangeland
- Forested Grassland
- Mountain Forest
- Urban



LAND USE

PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

5 0 5 10 MILES

SCALE 1:500,000

Cropland

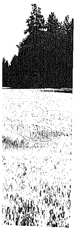
Table 3. Cropland Use, Palouse River Basin 1974

CROP	ACRES	PERCENT OF TOTAL CROPLAND
Wheat	598,000	49
Barley	159,000	13
Peas and Lentils	159,000	13
Summerfallow	305,000	25
Total	1,221,000	100

Source: 1974 Census of Agriculture, Whitman County, Wash., Latah County, Idaho.

Soft white winter wheat grown in the basin is excellent for pastry flour and bread flour blends. Some spring wheat is spot seeded on fields where fall wheat has been winter killed and on annually cropped fields in higher rainfall areas. In the low precipitation western basin, half the cropland is left fallow every year to build up soil moisture for cropping the following year.

Crop rotations in the 15-18-inch precipitation zone of the central basin include about a fourth fallow land, a third in wheat, and the remainder in barley, peas or lentils. With more than 18 inches of average precipitation the eastern basin is cropped annually to about half wheat and half peas or lentils.



Grain harvest in the eastern basin.

Table 4. Annual Farm Sales Comparison Palouse River Basin: Washington State

Annual Sales ($1,000)	Palouse Basin Percent of Farms	Washington State Percent of Farms
100	34	19
40-100	31	21
20-40	16	16
10-20	7	14
0-10	12	30

Source: 1974 Census of Agriculture, Whitman County, Wash., and Latah County, Idaho

Annual sales of products from the 2100 farms in the basin are much higher than state averages.

Total farm cropland returns for the basin in 1975 were approximately $147 million. Total cropland production expenses in the basin were $60 million in 1975. (m)

Cropland values have increased significantly in recent years, responding to higher crop prices and changes in farm commodity programs. Recent land sales in the basin have ranged from $300-400 per acre in the low-rainfall areas of the western basin to more than $1,200 per acre in the higher rainfall portions of the eastern basin.

Farmland and farm buildings in the Palouse River Basin are valued at more than $700 million.

Rangeland

Twenty-eight percent of the basin—597,000 acres—is rangeland. Palouse rangeland has both natural grasslands and shrub communities which occur in certain soils, wetlands and alkali areas. This land provides good forage for livestock and is important to various wildlife species. Rangeland areas generally are unsuited to cultivation because of steepness, frequent rock outcroppings, general stoniness, shallow soils, wetness, alkalinity, or elevation above irrigation systems. Most of the range is in the channeled scabland region of the western basin, where annual precipitation varies from 12-15 inches. Small areas are found also on the isolated buttes or along major drainages in the central and eastern basin.

Rangeland, which is of primary value for livestock production, is also important for watershed, aesthetics, and open space.

How people have changed vegetation through misuse of range can be seen by looking at present ratings of range conditions: about 8 percent are poor; 49 percent, fair; 33 percent, good; and only 10 percent, excellent (near-climax) condition.

Various range conservation practices could be implemented to improve range in poor to fair ecological condition.

Current livestock operations are primarily the cow-calf type. Ranches vary from a few hundred to several thousand acres. Most of the range is grazed during the spring, summer, and fall months. However, the trend has been to irrigate pastures and provide green forage during the hot, dry summer and fall months. Hay usually is fed for 90 days during the winter. This may vary from 30 days up to 5 months or more, depending on the location, and the severity of winter.

Livestock production is the major source of income on only 15-20 ranches. The remainder of the 590,000 acres of rangeland and 150,000 acres of grazed forest is owned by farmers who operate grain enterprises, with livestock as a secondary but important consideration. Beef cattle predominate. Small quantities of hogs, sheep, dairy cows, horses and poultry are raised in the basin. Annual livestock sales average $10 million.

Range grass is an important resource in the western basin.

Forest Land

The Palouse Basin has more than 225,000 acres of forest land, nearly 72 percent of which is in Idaho. These 163,000 acres have a continuity, annual yield, and proximity to industry and market which makes management practical. Despite varied ownerships, these forests provide a variety of products and recreation opportunities.

Forested Grasslands in the Washington portion of the basin are closely related to soils in which they grow. Most of the Washington forest is in the northern channel scabland area. In this area, open stands of ponderosa pine cover approximately 62,000 acres.

Average annual precipitation ranges from 16-20 inches. Elevations range from 1,600-2,000 feet. Areas of lower elevation and precipitation are mostly grasses. Ponderosa pine occurs with bluebunch wheatgrass and Idaho fescue where precipitation reaches about 18 inches. Ponderosa pine occupies flat areas on well-drained, moderately permeable soils and is found on moderate to steep slopes which rise, even slightly, above the general elevation of the basalt plain. Slopes along streams support ponderosa pine, leading down to poorly-drained soils supporting cottonwood and aspen. Natural reproduction occurs every 20-30 years, when good pine seed yields and favorable growing conditions coincide. Artificial reforestation is very difficult.

Shallow soils produce pine and native grass in the scablands.

The Turnbull Wildlife Refuge in the northern basin—managed by the U.S. Fish and Wildlife Service—covers approximately 13,000 acres of the forest in Washington. The timber is managed for wildlife and has not been harvested since 1973.

Elsewhere in the Washington Palouse, woodlands grow in strips along streams where soil moisture and precipitation provide enough water for tree growth. These strips are commonly in ponderosa pine, which grows well in loess soils. Cottonwood, aspen and willow are found on poorly-drained soils.

Douglas-fir grows on upland areas near the Washington-Idaho border where average annual precipitation is about 22 inches. These trees usually are found on north slopes where soil moisture is sufficient and soil temperature is lower. Generally, woodlands are found only on steeper slopes difficult to clear and farm. Woodlands in these areas generally are well stocked. All but those on shallow soils are capable of fairly high production. Because of good growing conditions and dense understory vegetation, stagnated thickets are uncommon.

Mountain Forest of the Idaho Palouse can be classified in associations with five major species: ponderosa pine, western white pine, western hemlock, grand fir, and Douglas-fir. The most noticeable characteristic common to the forest is that it is highly mixed.

The complexity of the cropland and timber patterns, as well as species composition of the forest, on state and private lands at lower elevations, is the result of land clearing and cutting practices.

The forest resource is a valuable and significant part of the economy in the Idaho Palouse. Thirty-nine percent of Latah County's forest resource is within the basin. Many people living near the forested areas in Idaho find employment in one of the two sawmills, others in log harvest, road construction, and forest management. Most people living in Potlatch, Princeton and Harvard are dependent upon the forest industry for their livelihood. Average annual stumpage value is estimated at $1.5 million. (Based on the average stumpage price of timber sold on publicly-managed lands during 1975). (n) Most of the forest is managed for a sustained yield of forest products, and these will continue to be an important part of the basin's economy.

Approximately 27 million board feet (international ¼" log rule) of sawlogs are produced annually in the Idaho Palouse. (n) This volume is produced from a standing inventory of approximately 1,264 million board feet.

Logs produced in the area are marketed at various mills in and adjacent to the basin. The Potlatch Company Mill at Potlatch is now used exclusively for production of 2-inch dimension stock. Better-grade logs are trucked to a standard sawmill at Plummer, Idaho. There is also a sawmill at Princeton, but logs are commonly trucked to mills outside the basin, such as those at St. Maries and Julietta.

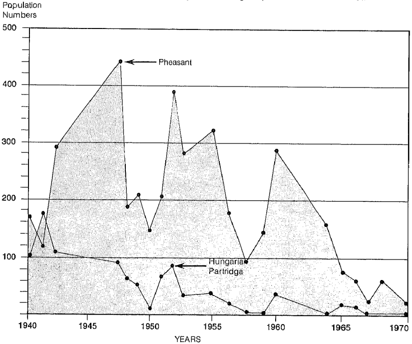
Logging in the upper watershed.

Fish and Wildlife

Resident fish and wildlife populations in most of the Palouse River Basin are generally low because of limited habitat. A small number of deer are in rangeland areas of the western basin, along streams and wooded areas of the central basin and in the mountain foothills of Idaho. Ring-necked pheasants occur in all but heavily forested areas of the eastern basin. Larger populations of pheasant occur in the central and eastern cropland portions of the basin, where there are more brush and grassy areas. (o) Large numbers of migrating waterfowl stop in the northwestern basin in spring and fall. Up to 50,000 birds have been observed at the Turnbull National Wildlife Refuge in the northern basin during fall migration. At least 15 species of ducks use the areas along streams and around lakes in the northwestern basin.

Once abundant populations of native and introduced upland game birds have been declining steadily since the early 1900's. The plight of wildlife in the Palouse is illustrated by the results of an upland game bird study on a 2,560-acre study area (the Colton Plot, Figure 3) between Pullman and Colton. This plot, which is typical of agricultural land in southeast Washington, has been studied intensively by various investigators for the past 30 years. (p)

Figure 3 Downward Trend Pheasant and Hungarian Partridge Population in the Colton Plot.



Source: *Poelker, R. J. and Buss, J. O.—Habitat Improvement The Way to Higher Wildlife Populations in Southwest Washington* Northwest Science, Vol. 46, No. 1, 1972.

Recreation and Tourism

Recreation opportunities in the basin are limited. Proximity to the Snake River, Blue Mountains, and many lakes in and near the basin, however, provides ample recreation opportunity for area residents. Recreation opportunities can be found at university athletic events and recreational programs. The main tourist sites are the universities, Palouse Falls, Steptoe Butte, McCroskey State Park (highland drive) and the Moscow Mountains.

Wildlife provides a significant amount of sport hunting. There was much opportunity for upland game bird hunting in the early 1900's, but this activity has declined steadily since the 1930's. Wildlife populations have been steadily declining in Washington State so, Whitman County still contributes a significant portion of the statewide harvest of pheasant, quail, chukar and Hungarian partridge.

Table 6. Game Harvest by Species; Whitman County, Washington—1975

Species	No. Harvested	Percent of Total State Harvest
Deer	290	a
Ring-Necked Pheasant	35,670	8
Ruffed Grouse	390	a
Ducks	9,250	1
Geese	830	1
Dove	5,100	2
Snipe	240	a
Rabbits	660	a
Jackrabbits	180	a
Rockchucks	7,830	11
Quail	21,000	8
Chukar	17,380	10
Gray (Hungarian Partridge)	22,000	36
Raccoon	20	a
Coyote	21,120	4

a = less than 1%
Source: Washington State Game Department

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PROBLEMS

Problems

Soil erosion is a major environmental problem in the Palouse River Basin. Erosion by runoff water, the most prevalent, removes the most soil. Soil blowing and tillage erosion also result in high soil losses.

Soil erosion by runoff is widespread during the period of November through March. Localized, high intensity rainstorms can cause heavy run off and serious soil erosion any month of the year.

Serveral kinds of soil erosion occur. Sheet and rill erosion affects the largest area and removes the most soil. All slopes of more than 3 to 5 percent are susceptible to sheet and rill erosion under certain weather conditions and land treatments. Soil slips occur on many steeper slopes. Silty clay soils on ridgetops are especially vulnerable to sheet erosion when rain strikes bare ground.

Other basin problems are related to erosion and sedimentation. Gully and stream channel erosion removes soil and deposits sediments on the fields as well as polluting streams. Productivity is being rapidly depleted as soils erode, increasing the need for mineral fertilizers.

Runoff and soil movement carry nutrients and pesticides that accumulate in the deposition areas or pollute the streams. Wildlife and fish populations are adversely affected, and environmental quality of the area is greatly reduced.

Water runoff, the major cause of soil erosion and sedimentation in the Palouse, results primarily from snowmelt during spring. Amounts and intensities of precipitation vary during the growing season. Most runoff occurs when the surface is frozen and snowmelt cannot penetrate the soil. The flow of water literally scalps the hills down to the frozen layer, carrying a large volume of sediment. Considerable lowland flooding, and varying amounts of streambank erosion also are common over the entire 170 miles of the Palouse River's length. The Palouse River drainage basin discharges approximately 3 inches of runoff per acre per year into the Snake River. Carried in and with these runoff waters are almost 3 million tons of sediment.

Sheet And Rill Erosion

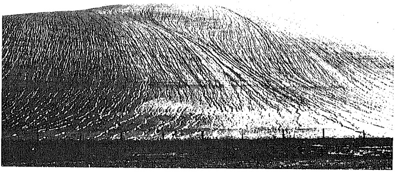
Cropland

Sheet and rill erosion have been observed since the early 1890's in the basin. As the original grass cover yielded to the plow, the soil began to erode.

Horses were replaced by tractors and the grass pastures were replaced by cultivated land. Increased size and speed of machines accelerated surface soil pulverization and subsurface soil compaction, which reduced its' natural ability to absorb moisture. Soil was tilled and aerated more frequently. Organic matter decomposed more rapidly than it could be replaced by natural processes. Erosion also took its toll of organic matter. As soil lost this natural sponge-like character the ability to absorb moisture was lessened and runoff increased. This in turn increased erosion.

Sheet and rill erosion in the Palouse is influenced by many factors. The most important of these are: kind of soil; length and steepness of slope; exposure; kind, amount, intensity and frequency of precipitation; temperature of the soil before and during precipitation or snow melt; kind and degree of previous erosion on the field, and land management.

People have little or no control over any of the factors except land management. Chief land management factors are: crop sequence, tillage, crop residue management, special erosion control measures, and plant cover.



Cropland Erosion

Historic Observations

An extended study of Palouse soil erosion offers clues to what happens, why, and how.

Beginning with the 1939—40 runoff season, an annual [a]survey has been made for the 1,040,000 acres of cropland in Whitman County, which contains the bulk of basin cropland. A visual appraisal is made of soil loss by rill, gully and soil-slip types of water-caused erosion on different land capability classes for up to 1,500 fields each year. At first, only fields planted to fall grains were studied. In later years, fields with other types of treatment were included. Fields were selected at random, but over the years an annual record has been kept on 10—20 "key" fields in the county.

The Alutin [b]method of rill erosion measurement was modified for basin conditions. Checks against research data several times during the 38-year period indicated survey data

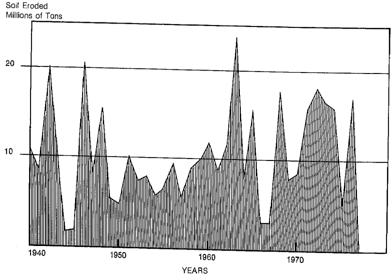
have an error not greater than plus or minus 25 percent.

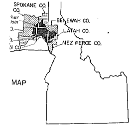
Erosion rates on the fields are plotted on a map each year. Different degrees of erosion severity are delineated. The map following page 34 shows the accumulated effects of these annual losses through the 1972 season. While data was collected through 1977, it was not included in preparing the map. The map would remain relatively unchanged if the data for 1972—1977 were included, however.

Soil loss rates have not been uniform. On an annual basis, they have had wide variations. A good example of this is the data for the 1975—76 runoff season, (map, preceding page 35) when an average of 15.1 million tons were washed from the fields. The following season only 604,000 tons, the lowest of record, were lost.

During the entire survey period to date, an average of 358 tons of soil has eroded from every acre of cropland in Whitman County.' That is equivalent to 9.2 tons of soil moving from each acre of basin cropland annually! Such a rate of erosion could remove approximately 2 inches of top soil from all basin land in less than 40 years. This is equivalent to the amount of material that would be required to cover eight city blocks eight-stories high.

Figure 4 Annual Sheet and Rill Erosion
Whitman County, Washington 1939-1977

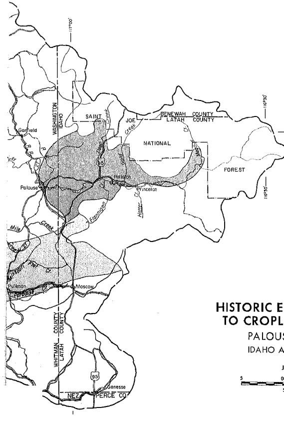




SOIL LOSS BY WATER EROSION 1939-1972 1/

Degree Of Erosion	Avg. Soil Loss Per Yr. Tons/Ac.	Total Soil Loss 28 Yrs. Tons/Ac.
None to Slight	0 - 2	0 - 60
Slight	2 - 7	60 - 200
Moderate	7 - 10	200 - 275
Severe	10 - 13	275 - 350
Very Severe	13 - 15	350 - 425
Extremely Severe	15 - 18	425 - 500

1/ Data from field survey by SCS Records for 4 years are missing.



HISTORIC EROSION DAMAGE TO CROPLAND 1939 - 1972

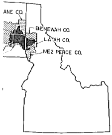
PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

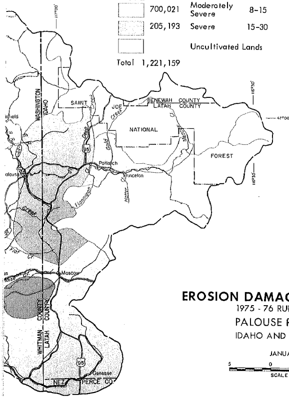
5 0 5 10 MILES

SCALE 1:500,000



EROSION DAMAGE ON CROPLAND

	Acres	Degree of Erosion	Tons/Acre All Cropland	Tons/Acre Fall Seeded Fields	Total Tons Loss
	76,740	Slight	0-3	3-5	153,500
	239,205	Moderate	3-8	5-10	1,280,500
	700,021	Moderately Severe	8-15	10-25	8,585,250
	205,193	Severe	15-30	25-50	5,130,000
		Uncultivated Lands			
Total	1,221,159				15,138,750



EROSION DAMAGE ON CROPLAND

1975 - 76 RUNOFF SEASON

PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

5 0 5 10 MILES

SCALE 1:500,000

Potential Soil Erosion[1]

A major effort of this study has been to develop a means of predicting rates of erosion in different precipitation and topographic zones and under a variety of cropping and management systems. Some method of estimating present conditions and predicting effects of changing management systems was needed.

The Universal Soil Loss Equation (USLE)[2] has been developed for this purpose. Soils, cropping patterns and management systems can be evaluated for potential soil erosion rates. The equation has been adapted to the Palouse by the Agricultural Research Service and the Soil Conservation Service.

Experiences and observations of the 38-year Whitman County erosion study were keys to establishing many of the values. Significant assistance came from field experiences of Soil Conservation Service and Cooperative Extension Service personnel.

Field data for USLE computation were collected on farms in 13 of the 20 soil associations in the basin. Most of the cropland in the basin is within these 13 associations. One 1,400-acre area was selected for intensive USLE analysis in each association.[3] Results of this analysis have been used to predict erosion rates under existing and alternative land management systems. Data presented is not specific as to sites. It is based on averages from the analysis. Actual erosion rates will vary because of site, climate, management, culture and similar influences.

[1]For sloping land only—does not include non-eroding bottom lands.

[2]See glossary for definition.

[3]See Appendix for detailed study methodology.

Palouse River Basin

Under current land management systems, projected soil erosion rates for the entire Palouse River Basin exceed 17 million tons per year—an overall average of 14 tons of soil for every acre of cropland in the basin.

Sheet and rill erosion have been serious with consistent problems, but intensity has been much lower in certain parts of the basin. Annual soil loss rates are usually lower in lower precipitation zones of the western basin and in high precipitation zones of the eastern basin. Highest average annual soil erosion rates have been consistently recorded in the intermediate 15- to 18-inch precipitation zone. Soil erosion rates are highest in this intermediate precipitation area because of the extremely steep topography, complexity of slopes, types of farming systems used and climatic conditions.

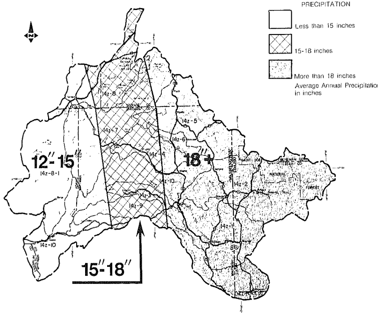
Table 8. Projected Average Annual Soil Loss Rates by Soil Association for Cropland with Existing Land Management System, Palouse River Basin

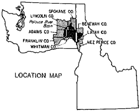
Precipitation Zone (In/Yr.)	Soil Association	Cropland Subject to Erosion (1,000 ac.)	Avg. Annual Erosion Rate[1] (tons/acre)	Potential Soil Loss Rate (1,000 tons)
Less Than 15	Walla Walla	44	15	660
	Anders-Benge-Kuhl	21	15	315
	Bagdad	17	15	255
	Stratford-Roloff-Starbuck	15	5	75
	Ritzville-Willis	11	5	55
	Others	12	15	180
	Subtotal	120		1,540
15-18	Walla Walla	108	21	2,268
	Athena	90	19	1,710
	Athena-Palouse	90	22	1,980
	Bakeoven-Tucannon-Cheney	25	10	250
	Others	49	18	882
	Subtotal	362		7,090
18+	Palouse-Thatuna	215	11	2,365
	Palouse-Staley	106	14	1,484
	Palouse-Thatuna-Naff	111	12	1,332
	Palouse-Thatuna-Tekoa	31	12	372
	Larkin-Southwick	33	7	231
	Freeman-Joel-Taney	11	12	132
	Helmer	3	6	18
	Santa-Carlington-Helmer	4	6	24
	Palouse	51	19	969
	Others	174	11	1,914
	Subtotal	739		8,841
	TOTAL	1,221		17,471

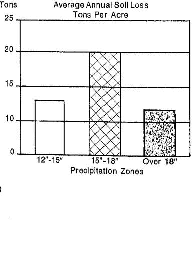
Basin Average Soil Loss (cropland) = 14 Tons/Ac.

[1]Average Annual Erosion Rate: Potential movement of soil from slopes. Does not imply movement from the field or into stream system.

Figure 6 Average Annual Soil Loss—Cropland
Palouse River Basin







Source: Base map prepared by SCS, Portland Carto. Unit from State Staff compilation. Thematic detail compiled by State Staff.

U.S. Department of Agriculture Soil Conservation Service.

Precipitation affects kinds of crops grown, intensity of farming systems used, types of tillage systems and equipment used, erosion rates and sediment delivery rates. Land management systems, combinations of crop rotations, tillage methods and structural treatments vary consistently by precipitation zones.

Low Precipitation Zone (less than 15-inch average annual precipitation)

The major cropping system used here is winter wheat and summerfallow. The summerfallow year is used to preserve precipitation from the noncrop year for the following winter wheat crop. Land is cultivated repeatedly during the fallow year for weed control.

Release of nitrogen, ordinarily needed for breakdown of crop residue and residual soil organic matter breakdown during this fallow period, reduces the amount of commercial nitrogen needed for the wheat crop.

Soil erosion ranges from 8 tons per acre annually under good stubble mulch in the wheat-fallow rotation to more than 23 tons per acre where the stubble or crop residue is depleted by repeated cultivation. More than 90 percent of the erosion occurs during winter on land planted to wheat following a season in summerfallow.

The overall average soil erosion rate for the area is projected at 13 tons per acre annually. (See page 38) Ninety percent of the more than 120,000 acres of cropland in this rainfall zone have an erosion problem. Annual soil erosion rates are predicted at 1.5 million tons per year.

Intermediate Precipitation Zone (15-18-inch average annual precipitation)

Farmers in this zone use two major cropping systems: Winter wheat and fallow or winter wheat, spring barley and fallow. (Some farmers use 2 years of spring barley after the winter wheat crop.) Summerfallow is practiced to insure good moisture for winter wheat, to control weeds and to enhance the natural release of nutrients from the soil. Summerfallow problems are compounded by two factors: higher rainfall and steeper slopes.

Predicted soil erosion rates, under the existing wheat-fallow system on individual farms, range from approximately 11 tons per acre to more than 30 tons per acre per year. With poor management, average erosion rates of more than 40 tons per acre per year are predicted under the wheat and fallow cropping system.

Farms where wheat, barley and fallow rotation is practiced also have high erosion rates. Some farms have an average annual erosion rate of more than 20 tons per acre. Soil erosion rates did not go below 8 tons per acre with this management system. Potential erosion on individual slopes averages almost 50 tons per acre on farms with the most severe topograph.

Average soil erosion rates of 20 tons per acre per year are predicted for cropland in the entire area. With more than 360,000 acres of cropland subject to erosion, annual soil erosion of over 7 million tons per year can be expected in this area, under existing land management systems. (See page 13)

High Precipitation Zone (More than 18 inches annual precipitation)

The predominant cropping system in this area is winter wheat and peas or winter wheat and lentils in rotation. Some farmers, however, annually plant small grain or use various combinations of winter wheat, barley and peas. A decreasing number of farmers also plant alfalfa, clover, and grasses in rotation with small grains, peas and lentils. Only small areas are summerfallowed. Major erosion problems are associated with low crop residues following pea or lentil crops.

The study indicated that—with limited tillage and fewer acres in peas or lentils—most farmers could hold soil erosion rates to an average of near 5 tons per acre annually.

Predicted sheet and rill erosion on cropland in the entire precipitation zone averages 12 tons per acre annually. (With most of the 740,000 acres of cropland in this area.) Total potential annual sheet and rill soil erosion can be expected to total almost 9 million tons if current land management systems are continued.

Rangeland

Erosion rates from rangeland vary, depending on range condition, soil, exposure, precipitation and slope.

In the Western United States, range soils can be expected to lose an average of 0-2 tons per acre annually under "natural" conditions (without human influence). These rates depend on soils, exposure, slope, precipitation and vegetative cover. When the range resource is misused, the soil erosion rate predicted for the same sites will exceed 2 tons per acre per year (accelerated erosion).

Based on present sampling techniques, the predicted soil erosion from rangeland in the Palouse River Basin at present is about 597,000 tons annually. This represents approximately 1 ton per acre average for the 597,000 acres of rangeland. Compared to erosion from cropland, these rates appear to be of lesser significance.

Erosion rates on rangeland can be reduced through various conservation practices: stockwater development to improve distribution of the livestock; fencing to regulate the time of year for grazing; brush management and noxious weed control; planned grazing systems to maintain enough cover to protect rangeland resources, and proper grazing of vegetation to sustain or improve ecological conditions. These practices will protect the resource and could increase "red meat" production from rangeland.

Mountain Forests And Forested Grasslands.

Erosion from mountain forests and forested grasslands average .39 tons per acre per year. These lands are in steep areas with high precipitation and shallow, marginal soils which can least afford erosion.

Forest land differs from cropland in that not all soils are disturbed each year by cropping. A typical harvest rotation cycle on forest lands is 100 years. Harvesting operations occupy any given area only two or three times during this period. After the initial road system is constructed and stabilized, erosion rates decline rapidly.

Sheet and rill erosion are the most common on the 225,000 acres of forest land in the basin. This amounts to an average of 72,890 tons per year, of which about 84 percent originates in Idaho. Sheet and rill erosion rates range from .06 to .57 tons per acre per year on undisturbed forest lands. Forested land disturbed by human activities—such as mining, road construction, logging, and skiing—have much higher rates: from .77 to 3.95 tons per acre per year.

Tillage Erosion

Tillage erosion is downhill soil movement on steep slopes caused by equipment such as the moldboard plow and one-way disk, which "turns" the soil. Heavy soil loss results when the furrow is thrown downhill especially when equipment is pulled at high speeds.

Most farmers in the high precipitation zone of the basin have used moldboard plows as the initial or primary tillage implement ever since the sod was first broken. Farmers, traditionally, plow the fields by turning the furrow downhill on the upper two-thirds of the hill. From 2 to 4 feet of soil has been plowed off the tops of sharp-topped ridges, exposing unproductive subsoil on these sites. The same thing is happening on upper slopes of the hills, but at a slower rate. Development of banks or "berms" along field edges is another problem commonly associated with tillage erosion.

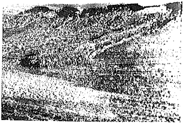
Banks or "berms" of soil 4 to 10 feet high are common at the foot of slopes where the furrow has been turned up against a fence. "Drop-offs" or cuts 16 inches to 3 feet high have been formed at the lower edges of areas planted to grass for 10 to 30 years. These high berms on steeply sloping land often result in another kind of erosion, "deep soil slips". (page 43)

Considerably less research has been done on the causes of tillage erosion than for water erosion. Field observations over a long period by Soil Conservation Service technicians indicated three factors are most important in determining the amount of soil lost by tillage in the Palouse. They are: (1) kinds of equipment used, (2) speed of operation, and (3) steepness of slopes. With present equipment, it is possible and practical to turn the furrow slice uphill on slopes up to about 25 percent gradient when using a moldboard plow. This is one of the basic reasons why the break between Class III and IV land was set at that figure for soils developed under grass cover in the Palouse region.

Deep Soil Slips

Deep soil slips occur on the steepest slopes and are closely related to snowdrifts and tillage erosion. Deep slips can occur on any soil when the soil profile becomes super-saturated with water. In the Palouse they occur most often on the Thatuna soils with slopes steeper than 40 percent, especially if the lower edge of the slope has been undercut by tillage erosion.

Deep soil slips often occur in the basin as late as May, a full month after the last significant spring rain. This usually happens after a deep, late melting snowdrift has covered the site. They often occur after a spring thaw when the lower soil profile is still frozen. A deep slip may remove as much as 300 to 600 tons of soil from a limited spot, leaving a deep scar which is impossible to farm over.



Excess moisture on frozen soil caused this soil slip.

Gully Erosion

In terms of soil erosion, gully formation, one of the most spectacular forms of erosion in the basin, is a minor problem compared with sheet and rill erosion in terms of tons of soil erosion. It is caused by concentrated flow of runoff water. When it does occur, sediment delivery is high. This kind of erosion is not common in all fields, nor does it occur every year. It usually occurs when winter rain falls on frozen soil. Fall plant growth simply does not protect exposed soil sufficiently under these conditions. When rain falls or snow melts, part of the moisture is absorbed by the soil; part evaporates, and the remainder runs down the hills. As runoff water accumulates, it forms tiny rills. Further on, rills sometimes come together. If the slope is long enough or steep enough, the rill will become so deep it can not be obliterated by normal tillage. Thus, a gully is formed.

Gullies were major problems in the 1920's and 1930's. In the mid-1930's, numerous erosion control structures and grassed waterways installed in the eastern basin did a good job of solving the gully erosion problem. Increased use of large machinery, removal of acreage controls, and lack of maintenance removed most of these gully control structures or made them ineffective. Grassed waterways have not been used extensively in the central or western basin because of difficulty in establishing effective grasses in lower rainfall areas.

Gully erosion is not a problem in the dense forested region of Idaho. However, in heavily grazed understory areas, gullies have been a minor source of erosion.

Stream Channel Erosion

Approximately 390 miles of stream channel in the Palouse River Basin have erosion problems. These eroded channels lose an average of 54.6 tons per mile per year. Effects of basin stream channel erosion vary widely. On steep upland forested areas, channel erosion averages 65.5 tons per mile per year—13 percent of all erosion from forest lands.

Mountain streams flow at high velocities and are frequently agitated by debris which deflects flow toward the banks. Brush, tree roots and rocks are the main source of bank stability throughout the forested basin. Many streams in the lower elevation areas have low gradients and flow at low velocities. They have a natural tendency to meander, which increases bank erosion. Grass sod is the primary stabilizer in cropland areas. If this cover is removed by water or mechanical means, erosion and sediment delivery are accelerated.

Erosion resulting from bedload movement is the primary cause of stream channel scour in fast flowing mountain streams. It is often accelerated by organic debris which constricts flow and increases natural streamflow velocity.

Bedload becomes a major problem when it settles out and plugs the low gradient streams. This accelerates flood frequency and bank erosion.

Channel erosion accounts for only a small part of the total basin erosion, but has the highest sediment delivery rate. During high runoff periods, damages to isolated areas on individual farms can be very high. Undercutting of highways, railroads and buildings by channel erosion has caused high monetary losses. Channel meander isolates fields and adds to the operating costs of farming.

Table 9. Soil Losses Due To Stream Channel Erosion By Drainage System, Palouse River Basin, 1978.

		Moderate to Severe		Slight	
Drainage System	Total Stream Length (miles)	Stream Length (miles)[1]	Avg. Annual Soil Loss (tons)	Stream Length (miles)[1]	Avg. Annual Soil Loss (tons)
Union Flat Creek	72	3	360	15	375
Rebel Flat Creek	20	6	720	10	250
Palouse River To Colfax	70	5	600	42	1,050
Downing Creek	10	5	600	3	75
North Fork Palouse	54	15	1,800	20	500
Deep Creek	12	6	720	3	75
South Fork Palouse	35	5	600	30	750
Cottonwood Creek	30	6	720	15	375
Pleasant Valley	16	—	—	8	200
Thorn Creek	16	10	1,200	6	150
Pine Creek	48	5	600	30	750
Idaho Forest Lands	150	35	332	104	8,322
Total	533	101	8,252	286	12,872

[1]Remainder of stream length has insignificant erosion

Wind Erosion

Wind erosion is often a problem in the western, and occasionally the central part of the basin during extremely dry years. Isolated areas of ashy soils, which contain little organic matter, will blow if strong winds come during dry conditions. Fields are most subject to damage when excessively tilled, thereby destroying soil structure, before adequate crop growth has occurred on the fallow land.

Dry cold winds often desiccate grain plants. Enough damage occurs to some fields to necessitate spring re-seeding. In many instances, these areas are not capable of producing a spring crop because of low precipitation. Consequently, overall production is reduced. During the average year, soil loss from wind erosion—even in the extremely low rainfall zones of the basin—is less than 1 ton per acre.

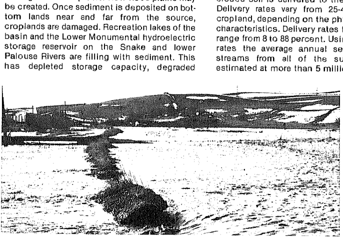
Water Quality

Sedimentation

Detrimental effects of erosion do not end with erosion of valuable topsoil. After soil has been washed from place of origin, some of it is deposited after traveling only a short distance; other, a considerable distance. Sediment can fill creek beds and lessen capacity to carry high flood flows.

Sediment can result in flooding and other damages to flood plains. New flood plains may be created. Once sediment is deposited on bottom lands near and far from the source, croplands are damaged. Recreation lakes of the basin and the Lower Monumental hydroelectric storage reservoir on the Snake and lower Palouse Rivers are filling with sediment. This has depleted storage capacity, degraded fishery habitat, increased dredging costs, and caused loss of recreation facilities—all of which adds up to millions of dollars in damages. Sediment is significant, not only in terms of voluminous soil loss, but because plant nutrients and other pollutants are transported with the soil particles.

In the Palouse River Basin, only part of the eroded soil is delivered to the stream system. Delivery rates vary from 25-45 percent from cropland, depending on the physical watershed characteristics. Delivery rates from forest lands range from 8 to 88 percent. Using these delivery rates the average annual sediment yield to streams from all of the subwatersheds is estimated at more than 5 million tons.



Bottom land covered with water during spring runoff.

Table 10. Estimated Average Annual Sediment Yield In Source To Stream System—Palouse River Basin

Source	Sediment Produced By Erosion—Tons	Delivery Ratio Percent	Sediment Yield—Tons
Cropland	17,471,000	30	5,167,000
Noncropland*	1,646,000	11	184,000
Stream Channels	21,000	90	19,000
Total	19,138,000		5,370,000

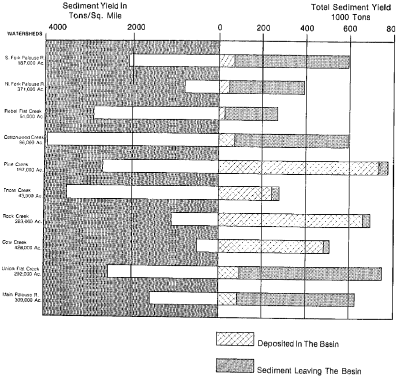
*Includes forest, rangeland, roads and other areas.

Not all of the 5.4 million tons of sediment leaves the basin. Much is deposited in basin lakes, stream channels or, as flood plain deposition.

Table 11. Average Annual Sediment Yield, Sediment Deposit And Sediment Leaving Palouse River Basin

Subwatershed	1,000 Acres	Total Sediment Yield Tons/Yr.	Sediment Deposited Within The Basin		Sediment Leaving Basin Tons
			Tons/Yr.	Location	
S. Fork Palouse	187	590,000	59,000	Channels & bottom land	531,000
N. Fork Palouse	317	390,000	39,000	Channels & bottom land	351,000
Rebel Flat Creek	31	232,000	23,000	Channels & bottom land	209,000
Cottonwood Creek	96	591,000	59,000	Channels & bottom land	532,000
Pine Creek	197	786,000	770,000	Rock Lake	16,000
Thorn Creek	43	231,000	226,000	Rock Lake	5,000
Rock Creek	283	661,000	648,000	Rock Lake	13,000
Cow Creek	428	508,000	498,000	Sprague, Finnel Lakes & Others	10,000
Union Flat Creek	202	762,000	76,000	Channels & bottom land	686,000
Lower Palouse—Mainstem	309	619,000	62,000	Channels & bottom land	557,000
		5,370,000	2,460,000		2,910,000

Figure 7 Predicted sediment yeild by watershed from existing land management systems.

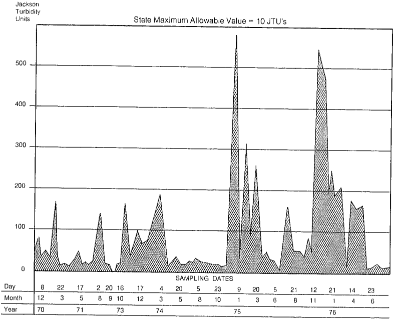


Sediment yields from watersheds within the basin vary significantly. Pine Creek watershed yields almost 786,000 tons—4 tons per acre—anually. In this watershed of 308 square miles, that is 2,474 tons per square mile. Cottonwood Creek watershed, with 151 square miles, has a predicted sediment yield of almost 591,000 tons—4,000 tons per square mile or 6 tons per acre.

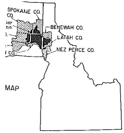
Sediment rates vary not only among subwatersheds, but from year to year and even from day to day. Close correlation between turbidity and sediment is not possible. Turbidity indicates water cloudiness caused by suspended solids. High sediment levels are the major cause of high turbidity levels in the Palouse River.

Turbidity data have been collected twice monthly at several locations in the basin. Samples were collected twice monthly at Hooper, near the mouth of the Palouse River: August 1970 through September 1971, and October 1973 through August 1976. They show frequent high turbidity. (Figure 8) Washington State water quality standards permit a maximum of 10 Jackson turbidity units beyond naturally-occurring concentrations for the lower Palouse River. Turbidity data indicates that the river seldom meets and often exceeds those standards significantly.

Figure 8 Water Sample Recordings in Jackson Turbidity Units, Palouse River Basin, Hooper, Washington



Source: Adapted from Washington State Department of Ecology and U.S. Environmental Protection Agency Data.



SEDIMENT DELIVERY
(to streams)

SHEET AND RILL EROSION
Tons/Sq. Mile

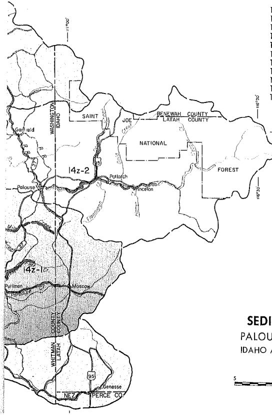
- 0-1,000
- 1,000-2,000
- 2,000-3,000
- 3,000-4,000

STREAMBANK EROSION
Tons/Mile

- 25-100
- Over 100

WATERSHEDS

14z-1	South Fork Palouse River
14z-2	North Fork Palouse River
14z-3	Rebel Flat Creek
14z-4	Cottonwood Creek
14z-5	Pine Creek
14z-6	Thorn Creek
14z-7	Rock Creek
14z-8	Upper Cow Creek
14z-8-1	Lower Cow Creek
14z-9	Union Flat Creek
14z-10	Palouse River



SEDIMENT YIELD

PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

5 0 5 10 MILES

SCALE 1:500,000

Nitrogen

Much of the nitrate in Palouse River water comes from subsurface drainage. When soil erosion rates are high, high nitrate levels also are carred into streams along with eroding soils.

Nitrate and ammonia concentrations are often high during winter and spring runoff. Nitrate levels during these periods are usually high enough to cause algae bloom in downstream lakes and reservoirs during the summer months.

Urban discharge of nitrogen occurs throughout the year.[d] During winter peak flow periods, urban discharges are overwhelmed by the heavy flows from rural reaches of the basin. Peak nitrogen levels of the Palouse River at Hooper, Washington often exceed 5 mg/l (Figure 9). Concentrations in smaller tributaries have been measured as high as 22-24 mg/l.

Most of the nitrate in runoff water from the basin, originates from agricultural lands, much results from subsurface drainage of these lands. Rainwater and snow in this area contain very little nitrogen. The soil surface which is most subject to soil erosion is low in nitrate concentrations when nitrate ions are leached down into the soil profile by percolating autumn rainwater. If high erosion rates occur before the nitrate are leached into the lower soil profile the runoff waters and the soil it carries will contain heavy concentrations of nitrate. Nitrogen fertilizers typically used in the region are applied in the fall and are injected about 8 inches beneath the soil surface. At this depth they are not normally picked up by sheet erosion but by severe rill erosion.

Ground water percolation of nitrate can add to water pollution problems. Studies indicate severe nitrate losses from fallow fields during the rainy winter months.

Ground water percolation of nitrate can add to water pollution problems. Studies indicate severe nitrate losses from fallow fields during the rainy winter months. A study conducted in 1971-72[e] near Pullman, Washington recorded low concentrations of nitrate from surface runoff and high levels from subsurface drainage.

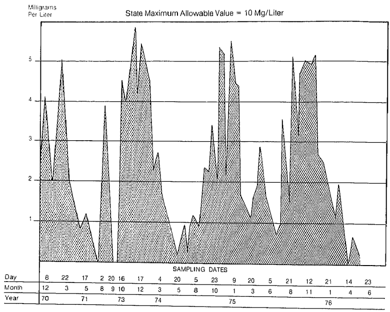
Phosphorus

Phosphorus is strongly bonded to soil particles. Therefore, soil phosphorus does not leach appreciably but is transported easily with soil from eroding fields. Total phosphate levels in the Palouse River at Hooper, Washington exceeded 1 mg/l in seven of 45 samples taken between October 9, 1974, and September 28, 1976. To date, state water quality standards have not been established for total phosphates. However, .01 mg/l is considered an indication of potential algae bloom problems.

Chemicals

Herbicides for weed control are the most common chemical applied in the Palouse River Basin. They usually are applied in the spring, after the high rainfall season. Nearly all studies indicate that, except when heavy rainfall occurs shortly after treatment, concentrations in runoff waters are very low. The total volume of herbicides running off the land during a crop year is much less than 5 percent of what was applied.[f] Toxicity of these chemicals is extremely variable; some can persist in the aquatic environment for a long time. Even very low levels of these chemicals in the runoff may be enough for environmental concern. Use of agricultural chemicals has increased with changing technology. Increased applications could cause higher levels of these materials in runoff waters unless erosion is reduced.

Figure 9 Nitrate and Nitrite Recordings, Palouse River Basin, Hooper, Washington



Source: Washington State Department of Ecology and U.S. Environmental Protection Agency.

Effects

Crop Yields[1]

Despite tremendous soil losses, crop yields have been increasing in much of the Palouse region. This deters efforts to get soil and water conservation on the land by reducing farmer and public concern about loss of the resource base.

A close analysis of grain yields, however, reveals that alarm about heavy soil loss is justified. Erosion ultimately will seriously damage the productive capacity of the land if allowed to continue.

Since 1934, the average yield of wheat in Whitman County has increased from about 26 bushels per acre to more than 50 bushels per acre. (See Figure 10). From 1934 to 1977, soil was eroding at an average rate of 9.5 tons of soil per acre each year. Soil erosion rates have averaged more than 13 tons per acre since 1970. Rates over 14 tons per acre are expected to continue if management does not change (see projections, page 37). Nearly three-fourths of a ton of soil was lost by erosion for every bushel of wheat produced.[2]

A common belief—that high crop yields can be maintained without erosion control—ignores the long term effects and is only part of the story.

During these four decades, erosion took about 5,000 acres of land out of production—including steep slopes where deep soil slips left sites impossible to farm. Soil was lost also from areas bordering main drainageways—so much soil that there isn't enough left above bedrock to farm.

Had it not been for declining soil resources, improved technology would have boosted average yields considerably above the present 50 bushels per acre figure. The combination of higher-yielding grain varieties—improved tillage—considerably more application of commercial fertilizer—and better chemical weed sprays since 1945 should have produced an average yield of 65-70 bushels per acre instead of the present 50 bushels per acre (Figure 10).

Most of the present yield increase is coming from good soil areas in each field—from areas where the original fertile topsoil has had only slight erosion damage. For example, hilltops with eroded topsoil produced an average of 15 bushels per acre in the 1930's. With today's improved technology, they produce an average of 35 bushels per acre, for an increase of about 20 bushels per acre. In both situations the increased grain yield barely pays the cost of production. Areas on lower slopes with about 2 feet of topsoil produced 50 bushels per acre in the 1930's and now produce 80-90 bushels per acre—an increase of 30-40 bushels per acre which is attributable to improved technology (See Figure 5). Eroded hilltops now encompass about 22 percent of the cropland (Classes IV and VI); non-eroded bottom lands, about 7 percent (Class II). As erosion continues, the average of land without topsoil continues to increase.

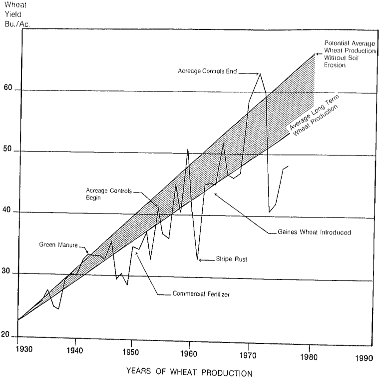
Thus, because improved technology has produced much greater benefits on non-eroded land than on eroded land, erosion is adversely affecting crop yields in the Palouse.

Each additional inch of topsoil (to a total of 24 inches) can increase yields by as much as 2.5 bushels of wheat per acre. Soil loss studies indicate that .05 inch of topsoil is lost from each acre of cropland in the basin each year—or an inch of soil every 20 years.[9] At this rate, the river basin loses an approximate 150,000 bushels of wheat production capacity each year. Using a rate of 50 bushels per acre, these 150,000 bushels are equivalent to losing 3,000 acres from production. Since 1935, the basin has lost productive capacity equivalent to 126,000 acres of cropland.

[1]SCS, "Crop Yield, Soil Loss & Management Table for Soils of Whitman County, Wash." June 1976.

[2]Kaiser, Verle G., Unpublished date—"Erosion Surveys of Whitman County, Wash." 1939-1977

Figure 10 Winter Wheat Production Loss From Soil Erosion—Palouse River Basin



Soil Moisture

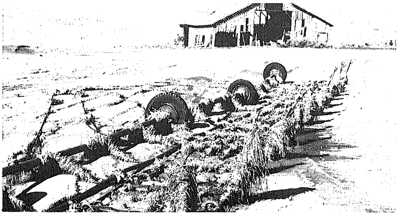
One reason for decreased productive capacity in the basin is loss of soil moisture holding ability. For holding moisture and air, soil with deep topsoil can be likened to a good natural sponge. When this sponge is lost, productive capacity of the soil decreases. Each additional inch of available moisture held in this sponge—beyond the 4 inches needed to produce the plant—can produce approximately 7 bushels of wheat. If moisture is not held in the soil, it runs off and causes erosion. Fields without severe erosion problems are approximately 3 times as productive as otherwise comparable fields that have lost all of the topsoil.[h]

Even the best farm managers have some erosion problems in the Palouse River Basin. Some erosion will occur on virtually all slopes under any conservation treatment.

During years of greater-than-normal snowfall, deep drifts accumulate on steep, north and east facing slopes. When the drifts melt, serious erosion often develops on slopes below them. Severe rill and gully erosion slows down farming operations. Delays can increase fuel use, disrupt schedules for farming operations and critically affect planting and weed control operations. Some rills become so deep farmers have to cultivate over them and replant winter wheat to spring crops, thereby reducing income. Harvest may be slowed because of rough, rilled fields. Equipment breakage problems increase and access to portions of some fields with trucks and other equipment often is limited.

Sediment on flat bottom land areas can smother crops. Weed control problems in bottom land areas increase. Increased costs from crop loss, reseeding, reduced use, and cleanup of the areas can be extensive. Cleaning ditches and waterways requires special equipment which adds to farm operating costs and inconvenience. Because sediment deposition makes it difficult to maintain grassed waterways, some farmers have abandoned them during the last 15 years. Field drains again are being damaged by gullies. As water travels overland following a flood, extensive scour often accompanies other flood damage.

Most major drainage systems in the basin have recurring problems with plugging by silt. As silt fills these areas, channel capacity to carry runoff water decreases. Crop losses and property damage resulting from the associated flooding can be very costly.



Excessive runoff causes severe damage.

Removal of silt from road and highway ditches is costly, too. Repairing 2,500 miles of county roads and 400 miles of state and federal highways damaged by sedimentation and erosion in 1968 was estimated at $500,000.[i] This annual cost is now estimated at $1 million.

Erosion has significant direct impacts on wildlife. As soil is depleted, capacity of land to produce wildlife and wildlife habitat is diminished. Relationships may be subtle. In intensively farmed areas such as the Palouse, reduction of wildlife populations by erosion may be reversed at first as eroded areas are abandoned to native vegetation. But as the soil resource is lost, so too will wildlife population decline. Wildlife numbers have declined sharply as cover has been removed for high intensity farming.

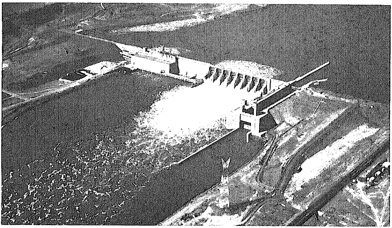
Removal of silt from road systems is costly.

Severe sedimentation, intermittent streamflows, and high water temperatures limit fish populations in the basin streams. Most Washington reaches of the streams are unsuitable for fish, particularly valued game fish such as trout. Usefulness of Rock Lake and Sprague Lake for fisheries has been severely impaired. Fish populations are affected because of the sediment-covered spawning beds in streams of the basin. Penetration of light into the lakes is drastically reduced by high sediment levels. Lack of adequate light has reduced growth of algae, the base of the food chain for fish in these lakes.

Wildlife habitat gives way to modern farming operations.

Recreation And Hydroelectric Power

Impacts on downstream reservoir sites also are significant. For example, the U.S. Army Corps of Engineers originally considered water-based recreation sites at 27 places in connection with multipurpose dams along the Snake River. Plans for developing 24 of these were abandoned because of high levels of erosion and sediment in the basin.[1] Reservoir capacity of Snake River dams is double that required for project life power generation. The reason is to handle silt deposits during the next 50 years.



Lower Monumental Dam on the Snake River

[1] U.S. Army Corps of Engineers, Walla Walla District, March 1973.

Social And Economic

Erosion and sediment from the Palouse River Basin have resulted in persistent and varied social and economic problems, some of which have had significant effects on erosion control decisions and measures. National farm programs, land ownership, market limitations, time, risk, and farm income levels all affect decisions on whether to implement the measures that would reduce erosion.

Some U.S. farm programs were instituted to help farmers stay economically sound. They have dealt, for example, with problems of erratic crop production, changes in labor requirements and scientific and technical improvements. The original Agricultural Adjustment Act reduced production and provided crop support payments as key elements. Farm surpluses had a major impact in the Palouse between 1954 and 1972 by spawning programs to limit production through acreage controls.

Price support payments were based on average individual farm yields. To meet acreage restrictions, farmers reduced wheat plantings. Since alternate crops generally could not be substituted because they were either under acreage controls or unsuited for climatic conditions, most farmers achieved acreage reduction by increasing summerfallow. This not only helped reduce the wheat acreage but also improved average yields through collection of additional moisture in the soil and releasing soil nitrogen. As yields increased in response to the summerfallow, support payments based on average yields also increased.

Average annual soil erosion rates increased to 11.7 tons per acre during this period, compared with about 8.3 tons per acre per year in previous years. Basin cropland, soil loss during the 13 years the summerfallow provision was in effect (1960-1972), is estimated at almost 54 million tons.

Additional research on new and better ways to stop erosion and workable incentives to accomplish application of conservation practices is needed. Past research has been very effective in developing new crop varieties, chemicals for weed control, and improvements in crop yields. These developments have been very effective in increasing production and maintaining farm income levels. Continual high production has, in fact, helped mask the adverse effects of soil erosion. Research has shown how to control erosion. It is estimated farmers could reduce erosion by at least 75 percent through practices already known.

Technical assistance programs have been effective in reducing erosion problems on many farms. Much more is needed, however. Much time and money has been directed successfully to land users willing to cooperate in solving erosion problems. Many who have equally severe problems have not sought help in solving them. In some instances, technical assistance efforts have not been effective in getting farmers to apply practices with maximum conservation benefits. Efforts to encourage use of practices such as minimum tillage and surface residues often have not been successful. Farmers have often been more interested in installing improved drainage systems, sediment collection ponds or small gully control structures which have minimal conservation benefit.

Conservation cost-share programs often have been used for more profit oriented practices to control erosion. For example: in 1975, \gricultural Conservation Program spent $122,713.00 in Whitman County. Almost $98,000 of this was used for underground tile drainage, which has minimal erosion control benefits. Funds were available for more effective conservation practices but few farmers applied these practices. The federal government pays up to 75 percent of the cost, but this has not caused enough farmers to apply these conservation practices to the land.

Many concerned conservationists believe owner-operators are better soil stewards. However, only 18 percent of the land is farmed by full-time, operator owners and the remainder by part-time owners or tennants. Owner-operators are usually more willing to apply conservation practices. The owner-operator usually knows if his land has problems needing conservation treatment. The owner-operator does not have a landlord to disagree with on who should pay for application of conservation practices.

Increased mechanization on grain farms affects soil resources of the area, both helping and hindering soil and water conservation. Modern tractors and tillage equipment make it possible to farm larger acreages. The trend toward wider equipment prevents farmers from treating smaller units of land according to their soil and site limitations. Modern farm machinery also promotes soil and water conservation: new tools have higher clearance and sturdier frames, making it possible to operate in heavier stubble. Hydraulic controls facilitate strip-cropping and farming adjacent to waterways and terraces.

Long-term records throughout the basin substantiate that soil conservation pays. Cropping systems that require less tillage usually are less costly and better for the land. Farms with high surface residue and low erosion rates usually have more moisture available to produce a crop. Farmers who learn how to control erosion usually realize greater economic benefits.

Operating costs and prices received for products influence erosion problems. As crop prices decrease, a farmer often places minimal value on his own labor. This may lead to tillage operations damaging to the soil. For example, chemical weed control usually requires less labor and high material costs. Tillage labor requirements are high and material costs, low. If the farmer has placed a low value on his labor, usually he will choose the tillage program.

Supply and demand can impact farming dramatically. Without price support programs, prices received for the basic soft white winter

wheat crop can fluctuate greatly. Based on recorded data, assurance of higher per-acre yields on summerfallow ground has been preferred to the combined risk of low yields and low income in low rainfall years under recrop farming systems.

Time affects erosion problems in the basin, too. When conservation practices are incorporated into a management program, timing of such farm operations as seeding, weed control, and harvest often becomes more critical especially under annual cropping.

Overall farm income in the Palouse River Basin is usually good even from operations with the highest soil loss rates. Good crops make some farmers reluctant to change to less-erosive practices even though most conservation practices bring better economic returns over long periods. The short-term risk of reduced income during low rainfall years often is greater to farmers practicing conservation.

The costs of applying conservation practices—which can vary extremely—also influence whether farmers will use them. Various practices and costs are discussed in Chapters V, and VI, Responses to Conservation Practices and Resource Evaluation.

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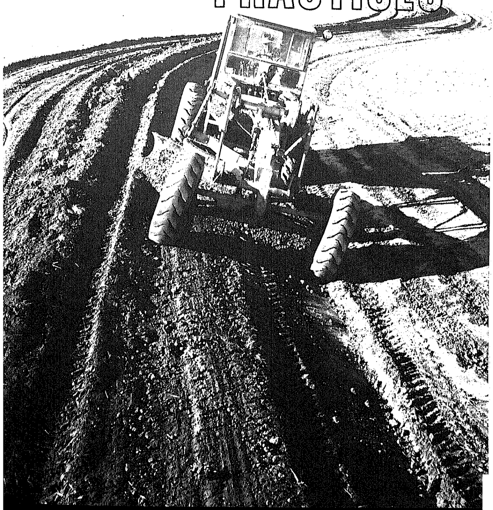
RESPONSES TO CONSERVATION PRACTICES



A

Responses to Conservation Practices

As a result of sheet and rill erosion during the past 40 years, Palouse cropland soils have eroded at an average rate of 9.5 tons per acre per year. Unless management of the land is changed in the next 40 years, this rate is predicted to be 14 tons, using the USLE. What can be done? Are there solutions that will reduce erosion effectively? Can a farmer have flexibility in crops he grows and the conservation practices he uses? In this section are some answers to these questions.

Unless a farmer is willing to move to another area, he must farm the soil he has. Length and steepness of slope and north-south or east-west field exposures have been formed by nature. Climate—more specifically; precipitation—has patterns over which the farmer has little control. Each of these natural factors affects how, when and to what extent erosion occurs.

The farmer usually has control over how he uses and manages the land resource: kinds of crops sequence for growing them; tillage practices; planting times; residue use and erosion control.

Each decision has a specific impact—good or bad—on erosion rates. Each decision also affects other decisions in a complementary or negative way even cancelling out other decisions. Management is a series of interacting decisions to influence achievement of the farmer's goal.

If conservation is an important goal, a farmer must make management decisions to reduce erosion to desired levels. The management system must be tailored to the individual farm: to crops grown, soils, topography and climate.

Results

This study has determined what rates of erosion can be expected from various crop rotations and conservation practices anywhere in the basin. Erosion rates differ for each of the three major precipitation zones and for the four land capability classes within each precipitation zone. Erosion rates shown are not specific to sites. They are based on averages from field data collected in the study. Actual erosion rates will vary due to site, climate, management, cultural and similar influences.

"Land Capability Class" is a practical grouping of soils by factors that influence production: erodibility, slope, depth, surface texture, subsoil permeability, water holding capacity and annual precipitation. These add to the complexity of farming. Cropland soils in the basin have been grouped into four land capability classes.

Class II soils have few limitations or hazards. Erosion rates are low, and only simple conservation practices are needed to control erosion. Slopes of most Class II land in the basin are less than 7 percent. Approximately 7 percent of the cropland in the basin is Class II.

Class III soils have more limitations or hazards than Class II soils. They can have severe erosion problems. Slopes generally range from 7 to 25 percent. They need more complex conservation practices. Approximately 71 percent of the cropland in the basin is Class III.

Class IV soils have greater limitations or hazards than Class III soils. Erosion is very difficult to control and erosion rates usually are high. They need very complex conservation practices if erosion is to be controlled. Slopes range from 25 percent to 40 percent on most soils. Approximately 15 percent of the cropland in the basin is Class IV.

Class VI soils have severe limitations or hazards. They are considered unsuited for cultivation because of erosion problems, shallowness and/or steep slopes. Approximately 7 percent of the cropland in the basin is Class VI.

Soil erosion rates are different for each land capability class (lowest in Class II and highest in Class VI) and each precipitation zone. They also differ in relation to the cropping system used.

In the Palouse, annual precipitation is the major single determinant of what can be grown. Major crop rotations that can be used in the various precipitation zones are shown in Table 12. The average soil erosion rates for each of these crop rotations with "no conservation management" is shown also.

Selection Of Crop Rotations

The farmer must decide how he is going to farm his land. The first decision is what crops to grow and in what sequence. The annual precipitation of the area in which his farm is located has major significance on the practical choices available to him. The crop rotation that is selected has major impact on the potential erosion rates.

Table 12. Predicted Average Annual Soil Losses by Crop Rotation by Precipitation Zones with No Conservation Management[1]

Precipitation Zone	Crop Rotation	Erosion Rate
Less than 12"	WHEAT FALLOW	8 T/Ac.
12"-15"	ANNUAL GRAIN	15 T/Ac.
	WHEAT-BARLEY-FALLOW	17 T/Ac.
	WHEAT-FALLOW	23 T/Ac.
15"-18"	ANNUAL GRAIN	20 T/Ac.
	WHEAT-BARLEY-PEAS	22 T/Ac.
	WHEAT-BARLEY-FALLOW	23 T/Ac.
	WHEAT-PEAS	25 T/Ac.
	WHEAT-FALLOW	30 T/Ac.
18"+	WHEAT-PEAS-4 YRS. ALFALFA-4 YRS.	4 T/Ac
	ANNUAL GRAIN	10 T/Ac.
	WHEAT-BARLEY-PEAS	11 T/Ac.
	WHEAT-PEAS	20 T/Ac.

[1]No Conservation Management, as used in this section, reflects a field condition with low surface residue, late fall germination, excessive soil pulverization and farming without regard to the slope of the

Two major factors can be attributed for differences in erosion rates on similar crop rotations in different precipitation zones: precipitation and topography.

Erosion rates are higher in the 15-18" precipitation zone than the 12-15" precipitation zone. Erosion rates for annual grain are lower in the over 18 inch precipitation zone because more crop residues can be produced than in the 15-18" precipitation zone. Less crop residue is produced in the 12-15" precipitation zone but erosion rates are lower because of more moderate topography and less annual precipitation. Extremely steep topography in much of the 15" to 18" precipitation zone also contributes to the high erosion rates in this area.

These erosion rates by land capability class are predicted for crop rotations with "no conservation management." Different conservation practices have different levels of effectiveness in reducing erosion. Conservation practices evaluated and displayed in the following branching charts are: Minimum tillage (for annual grain rotations), stubble mulching (for summerfallow), field stripcropping, divided slope farming, and terraces.

Each of these different conservation practices can reduce erosion rates at different levels. The average rate of erosion reduction resulting from each of these practices is shown on Table 13.

Table 13. Average Effectiveness of Conservation Practices— Erosion Reduction, Palouse River Basin by Precipitation Zone

	Precipitation Zone		
Conservation Practice	12-15" % Reduction	15-18" % Reduction	18"+ % Reduction
Minimum Tillage or Stubble Mulch	35	35	35
Field Stripcropping	28	15	24
Divided Slope Farming	28	15	24
Terraces	8	13	10

Minimum tillage and/or stubble mulch generally have the same effectiveness in all precipitation zones. The other practices differ in effectiveness because of topography. The study shows that field strips and divided slope farming are most effective in the high and low precipitation zones. Terraces would be much more effective if they could be applied to all the land. Much of the land is not suitable for terrace installation, however. The following branching charts show terraces can reduce overall cropland erosion rates by only 8-13 percent. Study results show that where slopes can be entirely protected with terraces, erosion rates can be reduced by 50 percent.

Management Effects

A series of branching line charts have been developed to show effects of various conservation practices. These charts provide flexibility in practice selection and in the order of application. If some conservation practices have been applied to the land already, the effectiveness of these and of applying additional practices can be determined. The charts also show relationships of conservation practices to soil erosion rates for each land capability class.

To use the branching charts, follow these steps:

1. Select the precipitation zone where the farm is located.
2. Select the desired crop rotation.
3. Note the average annual erosion rate for the crop rotation selected for the given precipitation zone.
4. Note the average annual erosion rates by land capability class for the crop rotation selected.

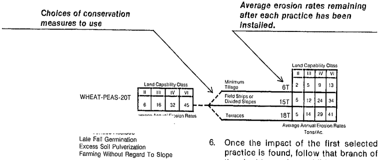
Example

(Step 1)
Precipitation Zone = 18 + Inches

		Average Annual Soil Erosion Rate in Tons/Acre			
		Land Capability Class			
Crop Rotation	All Land	II	III	IV	VI
Wheat-Peas	20 Tons	6	16	32	45
(Step 2)	(Step 3)		(Step 4)		

(Each land capability class is color coded on the charts for ease in identification of effects of applying additional conservation practices to these areas.)

5. Compare effects of various conservation practices on reducing erosion rates of the basic crop rotation.



6. Once the impact of the first selected practice is found, follow that branch of the chart to see how additional practice application will further reduce erosion.
7. For Conservation Practice descriptions see pages thru

MAJOR APPLICABLE ROTATIONS

Less than 12" Annual Precipitation

		Average Annual Soil Erosion Rates—Tons/Acre
Less Than 12" Precipitation	WHEAT-FALLOW	8 TONS

The above erosion rates reflect the influence of the rotation with a management system generally as follows: Conservation practices have not been applied. Fall seed germination is generally late; crop residues have been incorporated into the soil and not left on the surface. Tillage has reduced most clods to a very small size.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

Less Than 12" Annual Precipitation

WHEAT-FALLOW-8T	II	III	IV	VI
	2	5	11	32

Land Capability Class — Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

Practice		II	III	IV	VI
Field Strips or Divided Slopes	6T	1	4	8	23
Stubble Mulch	3T	1	2	4	11
Terraces	7T	2	5	10	29

Land Capability Class — Average Annual Erosion Rates Tons/Ac.

Practice		II	III	IV	VI
Stubble Mulch	2T	1	1	3	8
Terraces	5T	1	4	7	20
Field Strips or Divided Slopes	2T	1	1	3	8
Terraces	2T	1	2	3	10
Stubble Mulch	2T	1	2	3	10
Field Strips or Divided Slopes	5T	1	4	7	20

Land Capability Class — Average Annual Erosion Rates Tons/Ac.

Practice		II	III	IV	VI
Terraces	2T	1	1	2	7
Stubble Mulch	2T	1	1	2	7
Terraces	2T	1	1	2	7
Field Strips or Divided Slopes	2T	1	1	2	7
Field Strips or Divided Slopes	2T	1	1	2	7
Stubble Mulch	2T	1	1	2	7

Land Capability Class — Average Annual Erosion Rates Tons/Ac.

"This information is not site specific and individual locations may, due to site, climate, management, cultural, and similar influences experience values measurably different than those shown."

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR. 1977

MAJOR APPLICABLE ROTATIONS

12"—15" Annual Precipitation

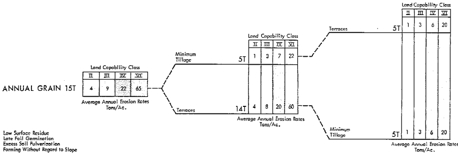
		Average Annual Soil Erosion Rates—Tons/Acre
	ANNUAL GRAIN	15 TONS
12"-15" Precipitation	WHEAT-BARLEY-FALLOW	17 TONS
	WHEAT-FALLOW	23 TONS

The above erosion rates reflect the influence of the rotation with a management system generally as follows: Conservation practices have not been applied. Fall seed germination is generally late; crop residues have been incorporated into the soil and not left on the surface. Tillage has reduced most clods to a very small size.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

12"–15" Annual Precipitation



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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

12"–15" Annual Precipitation

Land Capability Class

		II	III	IV	VI
Field Strips or Divided Slopes	12T	3	7	18	54
Stubble Mulch and Minimum Tillage	6T	1	3	9	26
Terraces	16T	4	9	23	69

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

		II	III	IV	VI
Stubble Mulch and Minimum Tillage	4T	1	2	6	18
Terraces	11T	3	6	17	50
Field Strips or Divided Slopes	4T	1	2	6	18
Terraces	5T	1	3	8	23
Stubble Mulch and Minimum Tillage	5T	1	3	8	23
Field Strips or Divided Slopes	11T	3	6	17	50

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

		II	III	IV	VI
Terraces	4T	1	2	6	17
Stubble Mulch and Minimum Tillage	4T	1	2	6	17
Terraces	4T	1	2	6	17
Field Strips or Divided Slopes	4T	1	2	6	17
Field Strips or Divided Slopes	4T	1	2	6	17
Stubble Mulch and Minimum Tillage	4T	1	2	6	17

Average Annual Erosion Rates Tons/Ac.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

12" - 15" Annual Precipitation

Average Annual Erosion Rates, Tons/Ac., by Land Capability Class

		II	III	IV	VI
WHEAT-FALLOW	23T	7	14	34	95

Low Surface Residue
Late Fall Seeding
Excess Soil Pulverization
Farming Without Regard To Slope

WHEAT-FALLOW-23T →		II	III	IV	VI
Field Strips or Divided Slopes	17T	5	10	24	68
Stubble Mulch	8T	2	5	12	32
Terraces	21T	6	13	31	87

Previous practice	Added practice		II	III	IV	VI
Field Strips or Divided Slopes (17T)	Stubble Mulch	6T	2	3	8	23
Field Strips or Divided Slopes (17T)	Terraces	15T	4	9	22	63
Stubble Mulch (8T)	Field Strips or Divided Slopes	6T	2	3	8	23
Stubble Mulch (8T)	Terraces	7T	2	5	11	29
Terraces (21T)	Stubble Mulch	7T	2	4	11	29
Terraces (21T)	Field Strips or Divided Slopes	15T	4	9	22	63

Previous practice	Added practice		II	III	IV	VI
Stubble Mulch (6T)	Terraces	5T	2	3	7	21
Terraces (15T)	Stubble Mulch	5T	2	3	7	.21
Field Strips or Divided Slopes (6T)	Terraces	5T	2	3	7	21
Terraces (7T)	Field Strips or Divided Slopes	5T	2	3	7	21
Stubble Mulch (7T)	Field Strips or Divided Slopes	5T	2	3	7	21
Field Strips or Divided Slopes (15T)	Stubble Mulch	5T	2	3	7	21

"This information is not site specific and individual locations may, due to site, climate, management, cultural, and similar influences experience values measurably different than those shown."

MAJOR APPLICABLE ROTATIONS

15"—18" Annual Precipitation

		Average Annual Soil Erosion Rates—Tons/Acre
15"—18" Precipitation	ANNUAL GRAIN	20 TONS
	WHEAT-BARLEY-PEAS	22 TONS
	WHEAT-BARLEY-FALLOW	23 TONS
	WHEAT-PEAS	25 TONS
	WHEAT-FALLOW	30 TONS

The above erosion rates reflect the influence of the rotation with a management system generally as follows: Conservation practices have not been applied. Fall seed germination is generally late; crop residues have not been incorporated into the soil and not left on the surface. Tillage has reduced most clods to a very small size.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

15" – 18" Annual Precipitation

Land Capability Class

		II	III	IV	VI
Minimum Tillage	7T	1	5	12	13
Field Strips or Divided Slopes	17T	3	13	31	32
Terraces	17T	3	13	31	32

Average Annual Erosion Rates Tons/Ac.

		II	III	IV	VI
Field Strips or Divided Slopes	6T	1	4	10	11
Terraces	6T	1	4	10	11
Minimum Tillage	6T	1	4	10	11
Terraces	15T	3	11	27	28
Minimum Tillage	6T	1	4	10	11
Field Strips or Divided Slopes	15T	3	11	27	28

Average Annual Erosion Rates Tons/Ac.

		II	III	IV	VI
Terraces	5T	1	3	9	10
Field Strips or Divided Slopes	5T	1	3	9	10
Terraces	5T	1	3	9	10
Minimum Tillage	5T	1	3	9	10
Field Strips or Divided Slopes	5T	1	3	9	10
Minimum Tillage	5T	1	3	9	10

Average Annual Erosion Rates Tons/Ac.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

15" - 18" Annual Precipitation

WHEAT-BARLEY-22T
PEAS

Land Capability Class

	II	III	IV	VI
WHEAT-BARLEY-22T PEAS	3	16	35	48

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

		II	III	IV	VI
Minimum Tillage	7T	1	5	12	16
Field Strips or Divided Slopes	19T	3	14	30	41
Terraces	19T	3	14	30	42

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

		II	III	IV	VI
Field Strips or Divided Slopes	6T	1	4	10	14
Terraces	6T	1	4	10	14
Minimum Tillage	6T	1	4	10	14
Terraces	16T	3	12	26	36
Minimum Tillage	6T	1	4	10	14
Field Strips or Divided Slopes	16T	3	12	26	36

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

		II	III	IV	VI
Terraces	5T	1	4	9	12
Field Strips or Divided Slopes	5T	1	4	9	12
Terraces	5T	1	4	9	12
Minimum Tillage	5T	1	4	9	12
Field Strips or Divided Slopes	5T	1	4	9	12
Minimum Tillage	5T	1	4	9	12

Average Annual Erosion Rat
Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

"This information is not site specific and individual locations may, due to site, climate, management, cultural, and similar influences experience values measurably different than those shown."

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR 1977

M7-OL-23877-4

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

15" – 18" Annual Precipitation

WHEAT-BARLEY-23T FALLOW

Land Capability Class	II	III	IV	VI
	3	16	44	50

Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

		Land Capability Class II	III	IV	VI
Field Strips or Divided Slopes	20T	3	14	37	43
Stubble Mulch and Minimum Tillage	8T	1	5	15	17
Terraces	20T	3	14	38	44

Average Annual Erosion Rates Tons/Ac.

		Land Capability Class II	III	IV	VI
Stubble Mulch and Minimum Tillage	7T	1	5	13	15
Terraces	17T	3	12	32	37
Field Strips or Divided Slopes	7T	1	5	13	15
Terraces	7T	1	4	13	15
Stubble Mulch and Minimum Tillage	7T	1	4	13	15
Field Strips or Divided Slopes	17T	3	12	32	37

Average Annual Erosion Rates Tons/Ac.

		Land Capability Class II	III	IV	VI
Terraces	6T	1	4	11	13
Stubble Mulch and Minimum Tillage	6T	1	4	11	13
Terraces	6T	1	4	11	13
Field Strips or Divided Slopes	6T	1	4	11	13
Field Strips or Divided Slopes	6T	1	4	11	13
Stubble Mulch and Minimum Tillage	6T	1	4	11	13

Average Annual Erosion Rate Tons/Ac.

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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

15" - 18" Annual Precipitation

WHEAT-PEAS-25T

Land Capability Class

II	III	IV	VI
4	19	45	55

Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

Land Capability Class

Practice		II	III	IV	VI
Minimum Tillage	9T	1	6	15	19
Field Strips or Divided Slopes	21T	3	16	38	47
Terraces	22T	3	17	39	48

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

Practice		II	III	IV	VI
Field Strips or Divided Slopes	7T	1	5	13	16
Terraces	7T	1	5	13	17
Minimum Tillage	7T	1	5	13	16
Terraces	18T	3	14	33	41
Minimum Tillage	7T	1	5	13	16
Field Strips or Divided Slopes	18T	3	14	33	41

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

Practice		II	III	IV	VI
Terraces	6T	1	4	11	14
Field Strips or Divided Slopes	6T	1	4	11	14
Terraces	6T	1	4	11	14
Minimum Tillage	6T	1	4	11	14
Field Strips or Divided Slopes	6T	1	4	11	14
Minimum Tillage	6T	1	4	11	14

Average Annual Erosion Rates Tons/Ac.

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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

15" - 18" Annual Precipitation

Land Capability Class

Practice	Tons	II	III	IV	VI
Field Strips or Divided Slopes	26T	3	20	48	58
Stubble Mulch	10T	1	8	19	23
Terraces	26T	3	20	49	59

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

Practice	Tons	II	III	IV	VI
Stubble Mulch	9T	1	7	16	20
Terraces	22T	3	17	42	50
Field Strips or Divided Slopes	9T	1	7	16	20
Terraces	9T	1	7	16	20
Stubble Mulch	9T	1	7	17	20
Field Strips or Divided Slopes	22T	3	17	42	50

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

Practice	Tons	II	III	IV	VI
Terraces	8T	1	6	14	17
Stubble Mulch	8T	1	6	14	17
Terraces	8T	1	6	14	17
Field Strips or Divided Slopes	8T	1	6	14	17
Field Strips or Divided Slopes	8T	1	6	14	17
Stubble Mulch	8T	1	6	14	17

Average Annual Erosion Rates Tons/Ac.

MAJOR APPLICABLE ROTATIONS

More than 18" Annual Precipitation

	Rotation	Average Annual Soil Erosion Rates—Tons/Acre
MORE THAN 18" Precipitation	WHEAT-4 YEARS ALFALFA-4 YEARS	4 TONS
	ANNUAL GRAIN	10 TONS
	WHEAT-BARLEY-PEAS	11 TONS
	WHEAT-PEAS	20 TONS

The above erosion rates reflect the influence of the rotation with a management system generally as follows: Conservation practices have not been applied. Fall seed germination is generally late; crop residues have been incorporated into the soil and not left on the surface. Tillage has reduced most clods to a very small size.

CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

Above 18" Annual Precipitation

WHEAT-PEAS 4 Yrs.-4T
ALFALFA 4 Yrs.

Land Capability Class

II	III	IV	VI
1	3	6	9

Average Annual Erosion Rates Tons/Ac.

Land Capability Class

Practice		II	III	IV	VI
Minimum Tillage	1T	1	1	2	3
Field Strips or Divided Slopes	3T	1	2	5	7
Terraces	4T	1	3	5	8

Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

Above 18" Annual Precipitation

ANNUAL GRAIN-10T

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

Land Capability Class	II	III	IV	VI
ANNUAL GRAIN-10T	3	8	16	23

Average Annual Erosion Rates Tons/Ac.

Practice		II	III	IV	VI
Minimum Tillage	3T	1	2	5	7
Field Strips or Divided Slopes	8T	2	6	12	17
Terraces	9T	3	7	14	21

Average Annual Erosion Rates Tons/Ac.

Following	Practice		II	III	IV	VI
Minimum Tillage 3T	Field Strips or Divided Slopes	2T	1	2	4	5
Minimum Tillage 3T	Terraces	3T	1	2	5	6
Field Strips or Divided Slopes 8T	Minimum Tillage	2T	1	2	4	5
Field Strips or Divided Slopes 8T	Terraces	7T	2	5	11	16
Terraces 9T	Minimum Tillage	3T	1	2	5	6
Terraces 9T	Field Strips or Divided Slopes	7T	2	5	11	16

Average Annual Erosion Rates Tons/Ac.

Following	Practice		II	III	IV	VI
Field Strips or Divided Slopes 2T	Terraces	2T	1	2	4	5
Terraces 3T	Field Strips or Divided Slopes	2T	1	2	4	5
Minimum Tillage 2T	Terraces	2T	1	2	4	5
Terraces 7T	Minimum Tillage	2T	1	2	4	5
Minimum Tillage 3T	Field Strips or Divided Slopes	2T	1	2	4	5
Field Strips or Divided Slopes 7T	Minimum Tillage	2T	1	2	4	5

Average Annual Erosion Rates Tons/Ac.

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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

Above 18" Annual Precipitation

WHEAT-BARLEY-PEAS .11T

	Land Capability Class II	III	IV	VI
WHEAT-BARLEY-PEAS 11T	4	9	18	26

Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

Practice		Land Capability Class II	III	IV	VI
Minimum Tillage	5T	1	5	8	13
Field Strips or Divided Slopes	8T	3	7	14	20
Terraces	10T	4	8	16	23

Average Annual Erosion Rates Tons/Ac.

Practice		Land Capability Class II	III	IV	VI
Field Strips or Divided Slopes	4T	2	4	8	12
Terraces	4T	1	2	7	9
Minimum Tillage	4T	2	4	8	12
Terraces	7T	3	6	13	18
Minimum Tillage	4T	1	2	7	9
Field Strips or Divided Slopes	7T	3	6	13	18

Average Annual Erosion Rates Tons/Ac.

Practice		Land Capability Class II	III	IV	VI
Terraces	3T	1	3	6	8
Field Strips or Divided Slopes	3T	1	3	6	8
Terraces	3T	1	3	6	8
Minimum Tillage	3T	1	3	6	8
Field Strips or Divided Slopes	3T	1	3	6	8
Minimum Tillage	2T	1	3	6	8

Average Annual Erosion Rates Tons/Ac.

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CONSERVATION PRACTICE EFFECTS

To Reduce Sheet and Rill Erosion

Above 18" Annual Precipitation

WHEAT-PEAS-20T

	Land Capability Class II	III	IV	VI
WHEAT-PEAS-20T	6	16	32	45

Average Annual Erosion Rates Tons/Ac.

Low Surface Residue
Late Fall Germination
Excess Soil Pulverization
Farming Without Regard To Slope

Practice		Land Capability Class II	III	IV	VI
Minimum Tillage	7T	2	5	9	13
Field Strips or Divided Slopes	15T	5	12	24	34
Terraces	18T	5	14	29	41

Average Annual Erosion Rates Tons/Ac.

Practice		Land Capability Class II	III	IV	VI
Field Strips or Divided Slopes	5T	2	4	7	10
Terraces	5T	2	4	8	12
Minimum Tillage	5T	2	4	7	10
Terraces	14T	4	11	22	31
Minimum Tillage	5T	2	4	8	12
Field Strips or Divided Slopes	14T	4	11	22	31

Average Annual Erosion Rates Tons/Ac.

Practice		Land Capability Class II	III	IV	VI
Terraces	4T	1	3	6	9
Field Strips or Divided Slopes	4T	1	3	6	9
Terraces	4T	1	3	6	9
Minimum Tillage	4T	1	3	6	9
Field Strips or Divided Slopes	4T	1	3	6	9
Minimum Tillage	4T	1	3	6	9

Average Annual Erosion Rates Tons/Ac.

"This information is not site specific and individual locations may, due to site, climate, management, cultural, and similar influences experience values measurably different than those shown."

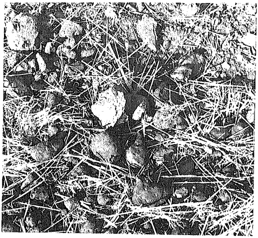
Practice Description

The branch charts list conservation practices that are commonly accepted and do reduce sheet and rill erosion. The list is short. Other practices could be applied, such as contour strips, but the physical difficulties and economic costs limited their consideration. The effectiveness of other conservation practices not shown here can be determined readily, however.

It should be noted that all practices are not equally effective in reducing soil erosion on varying classes of land. Classes II and III lands may not require or respond to practices necessary on steeper lands.

The following conservation practice sheets show the practices that are most effective, why they are effective, where they can be used, and things to consider in their use.

Minimum Tillage



Cloddy soil surface was created by limiting number and speed of tillage operations.

WHAT

Limiting the number and speed of tillage operations to preserve clods and crop residues for soil protection.

WHY

1. To improve intake of soil moisture.
2. To maintain a rough soil surface.
3. To reduce tillage costs.
4. To protect fall planted crops from winter winds.

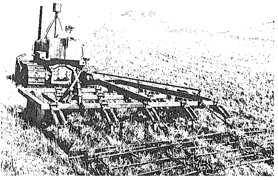
WHERE

On all cropland where crops are grown two years or more in succession.

THINGS TO CONSIDER

1. Timing of tillage operations to maintain cloddy surface.
2. Adequate weed control.
3. The need for adequate surface residues.

Stubble Mulch Tillage



Fall chiseling as the first operation to spread straw and weed seeds and to open to soil surface for moisture intake.

WHAT

Year-round management of crop residues to keep protective cover on soil surface.

WHY

1. To provide continuous surface cover to soil which will prevent wind and water erosion.
2. To maintain soil binding characteristics as long as possible.
3. To maintain good moisture intake and save soil moisture.

WHERE

On all dry cropland to be summerfallowed.

THINGS TO CONSIDER

1. Adequate clearance of tillage equipment.
2. Time tillage operations to retain maximum surface residues.
3. Weed control during wet periods.
4. Need for extra nitrogen during first few years.
5. Need for the right drill to seed in mulch.

Field Strips

Field strips of grain and fallow gives protection from runoff on this slope.

WHAT

Two or more strips of one or more crops alternated with grass or fallow across a slope to reduce erosion.

WHY

1. Altering cover conditions on a slope so protective cover absorbs runoff from more erosive strips.
2. To improve soil moisture intake ability.
3. To reduce snow drifting.
4. To reduce grain fire hazard.
5. To reduce fuel costs.

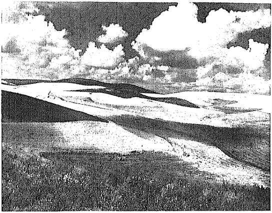
WHERE

On sloping dry cropland.

THINGS TO CONSIDER

1. Change strip edge location every two years to prevent formation of ridges.
2. Extra weed control at strip edges is needed.
3. Field access needs to be planned.
4. More management is needed to use fall stubble for livestock.
5. Use of grass strips in the system.

Divided Slope Farming



Wheat grown on upper slope, including hilltop, with dry peas on lower slope.

WHAT

Use of more than one crop or field condition to divide slopes.

WHY

1. Altering cover conditions on a slope so protective cover on part of the slope absorb runoff from more erosive portions of the slope.
2. To give surface protection to half of the slope at all times.
3. To keep tillage operations more nearly on the contour.

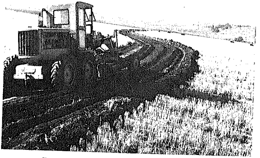
WHERE

On sloping dry cropland.

THINGS TO CONSIDER

1. Moving the cropline every second year to avoid ridges or dead furrows.
2. Extra weed control may be necessary where slope divides.
3. Field access needs planning.
4. If moldboard plow is used, turn furrow uphill.
5. Use of tillage implements other than moldboard plow.

Terraces



Terraces were installed to safely dispose of runoff water.

WHAT

A series of channels with supporting ridges across a slope to carry runoff water to a protected outlet.

WHY

1. To reduce the length of a slope and carry runoff water to a protected outlet.
2. To provide a cross slope line for tillage operations.
3. To reduce sediment in runoff water.
4. To prevent gully development.

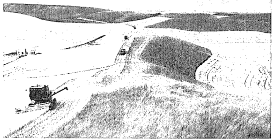
WHERE

On cropland field where slopes are less than 20 percent and suitable outlets can be provided.

THINGS TO CONSIDER

1. Suitable outlets must be planned for gradient terraces.
2. Field access must be considered.
3. Tillage near terrace may cause ridges to form.
4. Tillage will reduce terrace height.
5. Periodic maintenance is required.
6. Spacing of terraces and width of tillage equipment.
7. All field operations will change and should follow rather than cross terraces.

Retirement From Cultivation



Grass seeded on eroded hilltops to prevent loss of soil and water.

WHAT

Seeding grass and/or legumes or planting trees on areas subject to high erosion hazard, to provide permanent protective cover.

WHY

1. To provide continuous protective cover to soil surface.
2. To hold winter snow and reduce drifting.
3. To reduce deposition of eroded soil on productive lower slopes.

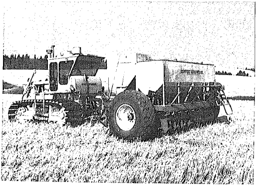
WHERE

On all steep cropland that is subject to severe water or tillage erosion.

THINGS TO CONSIDER

1. Soil slips can occur. Plow furrow should be turned uphill against the grass vegetation.
2. Extra weed control may be needed next to the grass seeding.
3. Field access must be planned.

No-Till Farming



Seeding winter wheat into a stand of undisturbed stubble with a special built heavy duty drill.

WHAT

No-Till Farming—Seeding a crop directly into a seedbed of undisturbed crop residues.

WHY

1. Soil surface is never exposed to wind and water erosion.
2. Soil structure is maintained.
3. Soil surface is always ready for intake of moisture.
4. Soil tillage is eliminated.

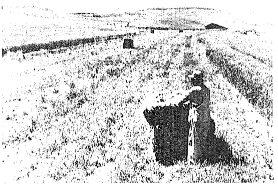
WHERE

On all dryland croplands of the intermediate and high precipitation zones.

THINGS TO CONSIDER

1. Adequate establishment of stand.
2. Reliance on herbicides for weed control.
3. Availability of proper drill.
4. Low plant vigor.
5. Limited research.

Grass Waterway



Grass seeded in field waterway to provide a protected area for runoff water.

WHAT

An area for disposal of field runoff water that is protected by vegetation.

WHY

1. To protect areas of concentrated flow against gully erosion.
2. To provide safe crossing with field equipment.
3. To provide a protected outlet for disposal of runoff water from terraces.
4. To provide a filter strip to remove silts from runoff water.

WHERE

In field areas where runoff water concentrates, that need protection against gully erosion.

THINGS TO CONSIDER

1. Amount of runoff water that will flow in it.
2. Adequate soil moisture for construction.
3. Good moisture at waterway seeding time.
4. Proper design, construction and maintenance.
5. Proper tillage to avoid ridges which may form at edge of grass.
6. Need for fertilizer and cutting of grass.
7. Damage to grass by equipment travel.
8. Need for hydraulic equipment.

Analysis of the branching charts, which follow page 69 shows that some conservation practices are much more effective than others.

Minimum tillage and/or stubble mulch on summerfallow ground will reduce erosion rates by approximately 35 percent over systems with "no conservation management".

Retirement of Class IV and VI land can reduce erosion rates by 50 percent. These areas emcompass 14 pecent of the land in the 12-15 inch precipitation zone, 27 percent of the land in the 15-18 inch precipitation zone, and 20 percent of the land in the over 18 inch precipitation zone. If these areas are retired from cultivation, it is expected that an additional 10-15 percent of the land would have to be retired also because of field access problems caused by the retirement.

No-till farming can be one of the most effective practices for erosion control. Since it is now in the early development stage, more research and testing are needed before this practice can be widely recommended or ap plied. For these reasons it has not been incluc ed on the branching charts. No-till farming ca reduce erosion rates to: 2 tons per acre in 12-1 inch precipitation zone, slightly over 2 tons pe acre in 15-18 inch precipitation zone an roughly over 1 ton per acre in the over 18 inc precipitaiton zone. Occasional (every other o every third year) use of no-till shows much pro mise. Studies are underway on improvement of no-till farming equipment to make the practice feasible.

Debris basins (barriers or dams constructed across a waterway or at other suitable locations to collect silt or sediment) can have beneficial long-term effects. They do not stop erosion but collect sediment before it becomes a problem in downstream areas. If other good land treatment practices are not applied, they usually fill with silt soon after construction. Construction costs are generally high.

RESOURCE EVALUATION

Resource Evaluation

The effects of applying conservation practices on cropland are discussed in this chapter.

The present condition (1975 cost-price base) is considered to be representative of future conditions if conservation measures are not applied. Future technological gains are expected to be offset by losses of productivity because of soil erosion.

For the 1975 base year, gross receipts from the 1,221,000 acres of cropland were estimated to be 148 million. These gross receipts are associated with a predicted annual sheet and rill erosion loss of 17.6 million tons. Approximately one ton of soil was lost for every $8.40 of income received.

This chapter will discuss and display the effects of conservation treatment for each precipitation zone. In addition, a present condition or future without action alternative, an alternative utilizing high residue management, an alternative providing the highest possible on-farm net income, and a maximum erosion reduction alternative for each precipitation zone are discussed and displayed. A recommended plan for implementation has not been selected since the various alternatives will be used in development of state and local water quality programs. Selection of a recommended plan would be inappropriate since the various alternatives will be used as decisions are made in implementing these programs. As PL 92-500 is implemented, various best management practices will be developed for the basin. The alternatives presented can be used to evaluate the potential environmental and economic impacts of those practices. Within the limitations of the study, one alternative has been identified as providing the greatest contribution towards environmental quality (EQ). The alternative that has the greatest contribution to economic development has also been identified (ED).

Following the discussion and display of the four alternatives for each precipitation zone is a section which discusses no till farming, conclusions, and implementation proposals.

Effects of Conservation Treatment Low Precipitation Zone
(12-15 inch annual precipitation)

If high residue management were applied reduction of erosion could be equal to the level possible from applying both terraces and divided slopes.[1] By applying high residue management returns could be increased. The maximum erosion reduction treatment[2] is high residue management with divided slopes and terraces. With this treatment, erosion could be reduced to 5 tons, a 62 percent reduction. Returns would be reduced $9 from the maximum level which would be achieved at the 8 tons per acre erosion level (a 46 percent reduction from present conditions) with all high residue management.

Wildlife habitat values in this precipitation zone are very low. Under present conditions, most cropland areas are estimated to have wildlife habitat values of less than 1 percent of those that could be expected if the area were managed for optimum wildlife habitat conditions. In the sample plot, approximately 99 percent of the area is used for crop production and only about 1 percent of the area has herbaceous cover. Present management of the cropland provides some food for wildlife. Lack of cover is the primary limiting factor. In addition, there is very little water available for wildlife. The application of most conservation practices will have very little effect on wildlife populations because the area will continue to lack permanent cover and permanent sources of drinking water.

[1]Divided slopes, also includes field strips where appropriate.

[2]Maximum Erosion Reduction; the maximum level possible without land retirement.

(table) pg. 100

Table 14. Effect of Conservation Treatment In Low Precipitation Zone-Palouse River Basin

Treatment	Erosion Rate Tons/Ac.	Gross Receipts $/Ac.	Production Cost $/Ac.[1]	Returns $/Ac.	Wildlife Habitat % Optimum[2]	Number Avian Species[2]
Present Cropping Systems & Residue Management Level	13	74	33	41	.2	8
w/Terraces	12	74	39	35	.2-.5	8-9
w/Divided Slopes[3]	10	74	36	38	.2-.5	8-9
w/Terraces & Divided Slopes[3]	8	74	42	32	.2-.5	8-9
w/High Residue Management	8	76	31	45	.5-.6	10-11
w/High Residue Management & Terraces	7	76	37	39	.5-.6	10-11
w/High Residue Management & Divided Slopes[3]	6	76	34	41	.5-.6	10-11
w/High Residue Management & Divided Slopes[3] & Terraces	5	76	40	36	.6	11

[1]Land cost of $39/acre have not been included in this table
[2]Compiled from G-9 evaluation plot
[3]Field stripcropping will be applied where applicable

Alternatives Analysis and Comparisons

The Present Or Future Without Alternative indicates that over 90 percent of the 120,000 acres is in a wheat-fallow cropping system. Presently, two-thirds of the operators using this cropping system are using better than average residue management; one third of the farms are retaining far less than the needed amount of residue required to stubble mulch.

The 10,000 acres of recrop barley is managed one half with minimum tillage and one half with a lower quality residue management.

The Second Alternative: Increasing Management To The Optimum Level. (E.D.) SCS field studies indicate high residue management usually results in more moisture being available for crop production and reductions in the number of tillage operations. This reduces production costs.

With annual grain, maintaining high residue levels requires fewer tillage operations; therefore, a savings in machinery and labor costs is achieved. Increased chemical costs

offset these savings. This alternative provided the highest level of economic development.

The Third Alternative: High Residue, Increased—Wheat—Barley—Fallow. This alternative allowed shifts in cropping systems as well as shifts in conservation practices. A linear program developed by the Economics, Statistics, and Cooperatives Service (ESCS) was used to analyze these conditions. The computer program selected the cropping system that would provide the highest possible return to land, capital and management for each erosion level.

Using this system, it is concluded that the highest possible economic return could be achieved when the erosion rate was about 8 tons per acre. This would result in a 46 percent erosion reduction. For this system, 40 percent of the cropland would be in a wheat-stubble mulch fallow system. Wheat-barley-stubble mulch fallow would occupy the remaining 60 percent of the cropland.

Alternative Four—The Maximum Erosion Reduction. (E.Q.) This alternative included maintaining present cropping systems, but increasing management to the optimum level, installing strips and terraces wherever possible, and seeding out all the Class IVe and VIe land plus 10 percent of the Class III land adjacent to the Class IVe and VIe land.

Terraces can be installed on an estimated 50 percent of the cropland. Erosion reduction rates and cost figures have been prorated on all acres in the precipitation zone. Fifty percent of the acres receive no benefit from terraces yet they have been included in the erosion and cost computations. In areas where terraces can be installed, they are a cost effective method of erosion reduction. For purposes of analysis, it has been assumed that terraces will cost about $6 per acre and will provide no benefit other than erosion control.

No increase in yield has been attributed to field strips or divided slope farming. Labor machinery costs will increase 10 percent. An amortized installation cost of $1 per acre has been included. Field strips or divided slopes are applicable to all cropping sequences except annual grain.

Within the limits of the study, this alternative provides the greatest contribution to environmental quality.
(See table 15)

Table 15. Effects Of Alternatives And Comparisons To Future Without

	Low Precipitation	Economic Development: Beneficial	Economic Development: Adverse	Environmental Quality: Beneficial & Adverse	Social Well-Being: Beneficial & Adverse
ALT #1	Future without action	Gross Receipts[1] $ Millions	Cost[2,3,4] $ Millions		
	73,000 acres of wheat-stubble mulch fallow	5.5	5.0	1. Predicted average annual sheet and rill erosion of 1.5, million tons per year. 2. Sediment delivery rate of 18%. 3. Sediment yield to streams of .3 million tons per year. 4. Wildlife habitat value of .2% of optimum. 5. Number of Avian species expected, 8/100 ac. 6. Use of 1.5 million gallons of fuel. 7. Use of 3.4 million pounds of fertilizer.	1. Produce 3 million bushels of wheat.
	37,000 acres of wheat-fallow	2.6	2.8		
	5,000 acres of minimum-till barley	.4	.4		
	5,000 acres of barley	.4	.4		
	The value to producers of outputs of goods and services	8.9			
	The value of on-farm resources required.		8.6		
	Net effects.	.3			
ALT #2	Future without action crops[5] with high residue management				
	110,000 acres of wheat-stubble mulch fallow	8.4	7.6	1. Predicted average annual sheet and rill erosion to .9 million tons; a 40% reduction. 2. Sediment yield to streams of .2 million tons; a reduction of .1 million tons. 3. Wildlife habitat percent of optimum increased from .2 to .6; a 4% increase. 4. Number of Avian species increase from 8 to 11; an increase of 3/100 ac. 5. Use of 1.5 million gallons of fuel. No change. 6. Use of 3.3 million pounds of fertilizer; a decrease of .1 million. 7. Possibility of future water quality improvement.	1. Produce 3 million bushels of wheat. 2. Average income increase from future without. 3. Risk of crop failure decreases. 4. Requires more technically-skilled operators. 5. Increase of educational requirements 6. Increased dependence on chemical weed control.
	10,000 acres of minimum-till barley	.7	.9		
	The value to producers of outputs of goods and services.	9.1			
	The value of on-farm resources required.		8.5		
	Net beneficial effects.	.6			
	Net effects compared to future without.	.3			
ALT #3	High residue, include wheat-barley-fallow				
	44,000 acres of wheat-stubble mulch fallow	3.3	3.0	1. Predicted average annual sheet and rill erosion reduced to 1 million tons; a 36% reduction. 2. Wildlife habitat percent of optimum increased .2 to .6; an increase of .4. 3. Number of Avian species increased 3 to 11/100 acres. 4. Fuel use 1.5 million gallons. No change. 5. Fertilizer use decrease .3 million pounds to 3.1 million pounds. 6. Sediment yield to streams of .2 million tons; a reduction of .1 million tons. 7. Possibility of future water quality improvement.	1. Reduce wheat production .4 million bushels to 2.6 bushels. 2. Average income increases. 3. Risk of crop failure increases. 4. Require additional technical ability. 5. Increase educational requirements. 6. Increase barley production. 7. Sensitivity to timeliness of operation increased. 8. Poor conservation farmers will have to find new vocations.
	76,000 acres of wheat-barley-stubble mulch fallow	5.7	5.8		
	The value to producers of output of goods and services.	9.0			
	The value of on-farm resources required.		8.8		
	Net effects.	.2			
	Net effects compared to future without.		-.1		

Table 15. Effects Of Alternatives And Comparisons To Future Without

	Low Precipitation	Economic Development Beneficial	Economic Development Adverse	Environmental Quality Beneficial & Adverse	Social Well-Being Beneficial & Adverse
ALT #4	Maximum erosion reduction,[6] Seed out 10% Class III, Class IV, and all Class VI lands will be seeded out.				
	78,000 acres of wheat-stubble mulch fallow	5.9	5.4	1. Removal of 35,000 acres of highly erosive cropland from production. 2. Reduce predicted average annual soil loss to about .2 million tons per year. A reduction of 1.3 million tons; an 84% reduction. 3. Wildlife habitat would increase to 4% of optimum; a 3.0 increase. 4. Acreage below seeded-out areas may erode at higher rates. 5. Number of Avian species increases to 15; an increase of 7/100 acres. 6. Use of fuel decreases to 1.4 million gallons; a .1 million-gallon decrease. 7. Fertilizer use decreases to 2.3 million pounds of fertilizer; a 1.1 million-pound decrease. 8. A sediment yield of less than .1 million tons per acre per year; a .2 million-ton reduction.	1. Eliminate the equivalent acreage of 35 farms from production. 2. Average income decreases. 3. Risk of crop failure decreases from future without. 4. May require some operators with high percentages of Class IV and VI lands to find other means of obtaining income. 5. Reduce wheat production .6 million bushels to 2.4 million bushels.
	7,000 acres of minimum-till barley	.5	.6		
	35,000 acres of grass seedings.		1.7		
	The value to producers of outputs of goods and services.	6.4			
	The value of on-farm resources required.		7.7		
	Net effects.		-1.3		
	Net effects compared to future without.		-1.6		

[1]Average Annual
[2]May require capital expenditure of $25,000 per 1,000 acre operating unit for stubble mulch equipment.
[3]Excludes cost of managerial ability, risk and any additional cost to operators with multiple holdings.
[4]Includes land cost based on current market value.
[5]Within the limitations of this study, this alternative is the Economic Development Plan.
[6]Within the limitations of this study, this alternative is the Environmental Quality Plan.

Effects of Conservation Treatment Intermediate Precipitation Zone
(15-18 inch annual precipitation)

In the intermediate precipitation zone, specified changes in cropping sequence were analyzed along with increments of land treatment application.

A three ton per acre soil loss reduction could be obtained by adding terraces, stripcropping or switching from a two year wheat-fallow sequence to a three year wheat-barley-fallow cropping sequence. Use of stripcropping or terraces would reduce income. Changing to a three year cropping system would increase returns $4 per acre. If a wheat-barley-fallow sequence is utilized; all slopes are divided and terraces are applied on all acres that can be terraced, erosion would be reduced to 15 tons per acre and income reduced $7 per acre from the present system. It is not possible to achieve more than a 25 percent reduction in predicted sheet and rill erosion rates unless the amount of high residue management is increased.

If the present cropping system is maintained and minimum tillage or stubble mulching is used on those acres presently not being treated, erosion could be reduced over 50 percent and income would increase $5 per acre. With high management, changing from wheat-fallow to wheat-barley-fallow is just as effective for erosion control as adding stripcropping or terraces. However, from a net return standpoint, changing cropping sequences is the most favorable. If cropping system changes, high residue management, stripcropping and terraces are applied, erosion can be reduced to 4 tons per acre. Returns would be increased $1 per acre from the present status at this maximum erosion reduction level.

As in other areas of the Palouse River Basin, wildlife population in this precipitation zone is limited by lack of permanent cover and drinking water. In the plots studied, only about 0.5 percent of the area has herbaceous cover and about 0.4 percent has shrubby or tree-type cover. Drinking water that is available to wildlife use is generally distributed at one-fourth to one-half mile intervals.

Application of conservation practices other than increase of areas with vegetative cover will have limited beneficial impacts on wildlife.

Table 16. Effect of Conservation Treatment, Intermediate Precipitation Zone— Palouse River Basin

Treatment	Erosion Rate Tons/Ac.	Gross Receipts $/Ac.	Production Cost $/Ac.[1]	Returns $/Ac.	Wildlife Habitat % Optimum[2]	Number Avian Species[2]
Present Condition	20	92	32	60	2.2	12
w/Divided Slopes[3]	17	93	34	59	2.2-3	12
w/Terraces	17	93	38	55	2.2-3	12
Transfer W-F to W-B-F	17	107	37	64	2.2-3	12
w/Divided Slopes[3] & Terraces	14	93	40	53	2.2-3	12
Minimum Tillage Stubble Mulch	9	96	31	65	2.2-3	12
w/Divided Slopes[3]	8	101	34	67	2.2-3	12
Transfer W-F to W-B-F	8	106	36	70	2.2-3	12
w/Terraces	8	100	37	63	2.2-3	12
Transfer W-F to W-B-F & Divide Slope[3]	6	107	39	68	2.2-3	12
w/Terraces & Divided Slopes[3]	4	101	40	61	3.1	12

[1]Land cost of $59/acre have not been included
[2]Compiled from G-1 evaluation plot
[3]Field stripcropping will be applied where applicable

Alternatives Analysis and Comparisons

Alternative I. Present Condition (Future Without Action) A wheat-fallow cropping system is used on 65 percent of the cropland in the medium precipitation zone. Forty percent of the operators using the wheat-fallow system utilize high residue management. Thirty-four percent of the cropland is in the less erosive wheat-barley-fallow cropping system. Sixty percent of the operators use the wheat-barley-fallow system with high residue management. Only about 1 percent of the area is in a wheat-barley-pea cropping system. This alternative produces gross receipts of $92 per acre. Production costs are $32 per acre and the predicted average annual sheet and rill erosion rate is estimated at 20 tons per acre.

Alternative II. Present Cropping System with High Residue Management Returns increased for all crops except annual grain when minimum tillage or stubble mulch were applied. Because of increased chemical cost, returns were reduced by a dollar per acre for the annual grain.

If the present cropping system is maintained and minimum tillage or stubble mulching is used on acres not being treated presently, erosion could be reduced over 50 percent and income would increase $5 per acre.

Alternative III. Maximum Income (E.D.) Alternative. The third alternative was developed by utilizing the ESCS linear program to develop solutions and emphasizing achievement of the highest level of net return for various levels of erosion reduction. Pea or lentil acreage was restricted to zero acres. To achieve maximum income levels in this precipitation zone, a cropping sequence of high residue wheat-barley-stubble mulch fallow produced the highest net returns. Returns would increase to $70 per acre and erosion would decrease to about 13 tons per acre; a 45 percent reduction in soil loss. Within the limits of the study, this alternative provides the highest level of economic development.

Alternative IV. Maximum Erosion Reduction (E.Q.) Alternative. For erosion reduction and wildlife habitat benefits, the retirement of the most erosive areas from cultivation offers the greatest potential for development of environmental quality alternative.

The relationships described with various levels of conservation application are consistent with the relationships described for the low precipitation zone. The only exception is terraces which can protect 20 percent of the cropland in this precipitation zone.

If all Class IVe and VIe land were retired from cultivation and high residue management, terraces and stripcropping or divided slope farming were applied to all remaining cropland in this precipitation zone, the predicted average annual soil loss would be 4 tons per acre per year. Net returns would be $47 per acre; a reduction of $18 per acre (28 percent) below the present condition.

Wildlife habitat values would increase from the present estimated level of 2.2 percent of optimum to 15.8 percent of optimum. Numbers of different bird species could be expected to double from present conditions with this alternative.

(See table 17)

Table 17. Effects Of Alternatives And Comparisons To Future Without

		Economic Development		Environmental Quality	Social Well-Being
	Medium Precipitation	Beneficial	Adverse	Beneficial & Adverse	Beneficial & Adverse
ALT #1	Future without action	Gross Receipts[1] $ Millions	Cost[134] $ Millions	1. Predicted average annual sheet and rill erosion rate of 7.2 million tons per year. 2. Estimated sediment delivery rate to streams of 15.6% or a sediment yield of 1.1 million tons. 3. Wildlife habitat value of 2.2% of optimum. 4. Number of Avian species expected, 12/100 ac. 5. Use of 5 million gallons of fuel. 6. Use of 10.5 million pounds of fertilizer.	1. Produce 10.5 million bushels of wheat.
	90,000 acres of wheat-stubble mulch fallow	8.1	7.9		
	147,000 acres of wheat-fallow	12.1	13.0		
	72,000 acres of wheat-barley-stubble mulch fallow	7.6	6.9		
	51,000 acres of wheat-barley-fallow	5.5	5.0		
	1,000 acres-wheat-barley-peas with minimum tillage	.1	.1		
	1,000 acres of wheat-barley-peas	.1	.1		
	The value to producers of outputs of goods and services.	33.5			
	The value of on-farm resources required.		33.0		
	Net effects.	.5			
ALT #2	**Future without crops with all high residue management.**				
	237,000 acres of wheat-stubble mulch fallow	21.3	20.8	1. Predicted average annual sheet and rill erosion rate 3.3 million tons per year; a reduction of 3.9 tons from future without a 55% reduction. 2. A sediment yield of .5 million tons; a .6 million-ton reduction. 3. A wildlife habitat value of 3%; increase of .8%. 4. Number of Avian species expected, 12/100 ac. No change. 5. Use of 4.2 million gallons of fuel; decrease of .8 million. 6. Use of 11.2 million pounds of fertilizer; increase of .7 million pounds. 7. Increase use of insecticides and herbicides will occur.	1. Increase wheat production to 11.2 million bushels. 2. Average income increases. 3. Risk of crop failure decreases. 4. Require additional technical ability. 5. Increase educational requirements. 6. Sensitivity to timeliness of operation increases. 7. Poor conservation farmers will have to find new vocations. 8. Possible need of $25,000 per farm for new equipment.
	123,000 acres of wheat-barley-stubble mulch fallow	13.0	11.8		
	2,000 acres of wheat-barley-peas minimum tillage.	.3	.3		
	The value to producers of outputs of goods and services.	34.6			
	The value of on-farm resources required.		32.9		
	Net effects.	1.7			
	Net effects compared to future without.	1.2			

Table 17. Effects Of Alternatives And Comparisons To Future Without

		Economic Development		Environmental Quality	Social Well-Being
	Medium Precipitation	Beneficial	Adverse	Beneficial & Adverse	Beneficial & Adverse
ALT #3	Maximum income alternative[5] 362,000 acres of wheat-barley-stubble mulch fallow.	38.6	34.8	1. Predicted average annual sheet and rill erosion rate of 2.9 million tons per year. A reduction of 4.3 million tons from the future without a 62% reduction. 2. Estimated sediment yield to streams of .5 million tons. 3. Wildlife habitat value of 3%; increase of .8%. 4. Number of Avian species, 12/100 ac. 5. Use of 5.6 million gallons of fuel; increase of 1.4 million gallons. 6. Use of 13.2 million pounds of fertilizer; increase of 2 million pounds. 7. Increase use of insecticides and herbicides.	1. Decrease wheat production to 8 million bushels per year. 2. Average income increases. 3. Risk of crop failure increases. 4. Additional technical ability required. 5. Sensitivity to timeliness of operation increases. 6. Poorer conservation farmers will probably have to find different means of employment.
	The value to producers of outputs of goods and services.	38.6			
	The value of on-farm resources required.		34.8		
	Net effects.	3.8			
	Net effects compared to future without.	3.3			
ALT #4	Maximum erosion reduction future[6] without cropping system with high residue management with divided slopes and terraces and 10% of the Class III lands, and all of the Class IV and Class VI seeded out.			1. Predicted average annual sheet and rill erosion rate 1.4 million tons per year. A reduction of 5.8 million tons from future with an 80% reduction. 2. Estimated sediment yield to streams of .2 million tons; a reduction of .9 million tons. 3. Wildlife habitat value of 20.5%; an increase of 18.3%. 4. Number of Avian species, 23/100 ac.; an increase of 11. 5. Use of 3.9 million gallons of fuel; a decrease of 1.1 million gallons. 6. Use of 7 million pounds of fertilizer; a decrease of 3.5 million pounds. 7. Increase use of insecticides and herbicides.	1. Decrease of wheat production to 7 million bushels of wheat. 2. Average income decreases. 3. Risk of crop failure decreases. 4. Loss of acreage equivalent to 133 farms. 5. 250 or more farms may be reduced to non-economic units. 6. Some economies of size will be lost. 7. Operators should be able to manage remaining acres at a higher level. 8. Opportunity for upland bird hunting would increase.
	150,000 acres wheat stubble mulch fallow with terraces and divided slopes	16.8	14.5		
	78,000 acres wheat-barley-stubble mulch fallow with terraces and divided slope	9.6	8.2		
	1,000 acres of minimum till wheat-barley-peas with terraces and divided slope	.1	.1		
	133,000 acres of grass seeded on the 16% of the Class III, all of the Class IV, and Class VI lands.		9.0		
	Value to producers of outputs of goods and services.	26.5			
	Value of on-farm resources required.		31.8		
	Net effects.		-5.3		
	Net effects compared to future without.		-5.8		

[1]Average Annual
[2]May require capital expenditures of $25,000 per 1,000 acre operating unit for stubble mulch equipment.
[3]Excludes cost for managerial ability, risk and any additional cost to operators with multiple holdings.
[4]Production cost does not reflect additional cost to operator with multiple holdings.
[5]Within the limitations of this study, this alternative is the Economic Development Plan.
[6]Within the limitations of this study, this alternative is the Environmental Quality Plan.

Effects of Conservation Treatment High Precipitation Zone
(over 18 inch annual precipitation)

In the high precipitation zone, an erosion rate of 6 tons per acre per year could be achieved by stripcropping and replacing fallow with recrop wheat without any improvement in management (Table 18). This cropping system would retain returns at present levels, but have $18 less return than if the fallow had been replaced by additional acres of peas. The system with peas would have had an erosion rate of 7 tons per acre and returns of $99 per acre.

If all acres could be managed with high residue systems, net returns would increase $8 per acre from the wheat-pea system with correct management skills.

There are at least eight systems that will have an erosion rate of less than 5 tons per acre. High residue wheat-pea systems with stripcropping will have returns of $104 per acre, an increase in net returns of $23 per acre over present conditions.

Wildlife habitat values in this precipitation zone range from 0.8 percent to 32 percent of optimum. The areas with the lowest values are nearly devoid of herbaceous cover and are lacking in potential sources of food and water for wildlife. The areas with the highest values have mixed vegetative cover including 25 percent of the area in non-cropland uses. These acres also have better management for wildlife uses. Water for wildlife is usually more easily accessible in these areas.
(See table 18)

Table 18. Effects of Conservation Treatment—High Precipitation Zone Palouse River Basin

Treatment	Erosion Rate Tons/Ac.	Gross Receipts $/Ac.	Produc-[1] tion Cost $/Ac.	Returns $/Ac.	Wildlife Habitat % Optimum[2]			
					1	2	3	4
Present Condition	14	143	60	83	0.8-1.1	2-2.4	17.6	32
Replace Fallow w/peas	10	167	68	99	0.8-1.0	1.2-2.0	12	28
w/Terrace & replace fallow w/peas	8	167	73	94	0.8-1.0	1.2-2.0	12	28
w/Divided Slopes[3] replace fallow w/peas	7	167	68	99	0.8-1.0	1.2-2.0	12	28
w/Terraces & Divided slopes & replace fallow w/peas	7	167	76	91	0.8-1.0	1.2-2.0	12	28
Transfer from fallow to recrop wheat	7	153	70	83	1.4-1.6	2.4-2.6	18-19	27-28
w/Divided slope & transfer fallow to recrop wheat	6	153	72	81	1.4-1.6	2.4-2.6	18-19	27-28
w/Terraces & transfer fallow to recrop wheat	6	153	76	77	1.4-1.6	2.4-2.6	18-19	27-28
w/Terraces & Divided slopes & transfer fallow to recrop wheat	6	153	78	75	1.4-1.6	2.4-2.6	18-19	27-28

[1]Does not include $80 per acre land cost.
[2]Wildlife habitat values in Column 1 are from plot G-5; Column 2, G-2; Column 3, G-4; and Column 4, G-6.
[3]Field stripcropping will be applied where applicable.

Table 18. Effects of Conservation Treatment—High Precipitation Zone Palouse River Basin (Continued)

Treatment	Erosion Rate Tons/Ac.	Gross Receipts $/Ac.	Production Cost $/Ac.	Returns $/Ac.	Wildlife Habitat %Optimum			
					1	2	3	4
HIGH RAINFALL ZONE								
Minimum Tillage Replace fallow w/peas	5	175	68	107	0.8-1.0	1.2-2.0	12	28
Add recrop wheat	4	158	71	87	1.4-1.7	1.4-1.6	18-19	27-28
w/Divided slope & transfer from fallow to recrop wheat	4	157	72	85	1.4-1.7	2.4-2.6	18-19	27-28
w/Terraces & transfer from fallow to recrop wheat	4	158	77	81	1.4-1.7	2.4-2.6	18-19	27-28
w/Terraces & divided slopes & transfer fallow to recrop wheat	4	157	78	79	1.4-1.7	2.4-2.6	18-19	27-28
w/Divided slope & replace fallow w/peas	4	175	71	104	0.8-1.0	1.2-2.0	12	28
w/Terraces & replace fallow w/peas	4	175	74	101	0.8-1.0	1.2-2.0	12	28
w/Terraces & divided slopes & replace fallow w/peas	3	175	76	98	0.8-1.0	1.2-2.0	12	28

Alternatives Analysis and Comparisons

Alternative I. Present Condition Or Future Without Action. The wheat-pea cropping system utilizes the largest amount of acreage in the higher precipitation zone. Over 40 percent of the cropland is in this system. About 50 percent of the wheat-pea acreage receives high residue management treatment. Another 40 percent of the cropland is in a wheat-barley-fallow cropping system. Sixty-five percent of this system is managed by maintaining necessary crop residues and clod sizes. Recrop wheat occupies the remaining 20 percent of this zone. The predicted annual sheet and rill erosion rate is 12 tons per acre. Gross receipts are $143 per acre. Production cost is $60 per acre.

Alternative II. High Residue Management. This alternative for the high precipitation area varied slightly from the second alternative of the other two precipitation zones. In this zone, there are summerfallow acres in the present situation. From a resource protection standpoint, summerfallow should be utilized only as a method of handling severe weed problems that cannot be controlled by other methods. Therefore, wheat-fallow and wheat-barley-fallow cropping sequences have not been included as alternatives.

Recrop wheat has been used to replace fallow in alternative II and IV. With high residue and the replacement of fallow, a 4 tons per acre predicted average annual sheet and rill erosion rate could be achieved — a 67 percent reduction. With this alternative, gross receipts could be increased $15 per acre from the present condition. Production cost would increase $11 per acre.

Alternative III. Maximum Income (E.D.) Alternative. This alternative would utilize a high residue wheat-pea cropping system on all 739,000 acres in the precipitation zone. This system would have net returns of $136 per acre ($53 above present conditions) and a predicted erosion rate of 8 tons per acre per year—a 43 percent erosion reduction from the present condition.

Alternative IV. Maximum Erosion Reduction (E.Q.) Alternative. This alternative of the high precipitation zone reveals that retirement of 10 percent of the Class III land and all Class IVe and Class VIe land would involve retiring approximately 20 percent of the cropland in the area from production.

This alternative also includes transferring summerfallow acreages to recrop grain, stripcropping and installing terraces on all lands where they can be used. This alternative would result in a predicted erosion rate of 2 tons per acre per year and net returns of less than $50 per acre. (A net return reduction of about 40 percent from present levels.)

Wildlife habitat values would increase and the numbers of bird species would nearly double from present levels. For this analysis, it has been assumed that income would not be generated from seeded-out land.

Table 19. Effects Of Alternatives And Comparisons To Future Without

	High Precipitation	Economic Development: Beneficial	Economic Development: Adverse	Environmental Quality: Beneficial & Adverse	Social Well-Being: Beneficial & Adverse
ALT#1	Future without action	Gross Receipts[1] $ Millions	Cost[2,3,4] $ Millions	1. Predicted average annual sheet and rill erosion loss rate of 12 tons per acre per year, or 8.8 million tons per year. 2. A sediment delivery rate of 28.75%, or a sediment yield to streams of 2.5 million tons per year. 3. Wildlife habitat value of 3% of optimum. 4. Number of Avian species expected, 12/100 ac. 5. Use of 13.2 million gallons of fuel. 6. Use of 55.6 million pounds of fertilizer each year.	1. Produce 23.2 million bushels of wheat.
	91,000 acres of recrop winter wheat with minimum tillage	12.5	14.3		
	50,000 acres of recrop winter wheat	6.2	7.8		
	188,000 acres of wheat-barley-stubble mulch fallow	19.9	23.0		
	100,000 acres of wheat-barley-fallow	9.8	12.6		
	149,000 acres of wheat-peas with minimum tillage	30.4	22.0		
	161,000 acres of wheat-peas	26.9	23.6		
	The value to producers of outputs of goods and sevices	105.7			
	The value of on-farm resources required.		103.3		
	Net effects	2.4			
ALT #2	**Future without crops with all high residue management and fallow acres replaced with recrop winter wheat**			1. Predicted average annual sheet and rill erosion loss rate of 4 tons per acre, or 3.3 million tons annual. This is a 5.5 million-ton reduction; a 67% reduction. 2. An estimated sediment yield to streams of .9 million tons per year; a reduction of 1.6 million tons each year. 3. Wildlife habitat value of 4% of optimum; a 1% increase. 4. Number of Avian species expected, 12/100 ac. No change. 5. Use of 16.9 million gallons of fuel; an increase of 3.7 million gallons. 6. Use of 69.8 million pounds of fertilizer each year; an increase of 14.1 million pounds. 7. Increase use of herbicide and insecticides.	1. Production increase to 27.4 million bushels of wheat - an increase of 4.2 million bushels each year. 2. Average income increases. 3. Risk of crop failure increases. 4. Additional technical ability required. 5. Sensitivity to timeliness of operation increases. 6. Poor conservation farmers will have difficulty continuing to farm.
	333,000 acres of recrop winter wheat with minimum tillage	45.6	52.2		
	288,000 acres of wheat-barley-peas with minimum tillage	46.9	41.0		
	118,000 acres of wheat-peas with minimum tillage.	24.1	17.4		
	The value to producers of outputs of goods and services.	116.6			
	The value of on-farm resources required.		110.6		
	Net Effects	6.0			
	Net effects compared to future without.	3.6			

[1]Average Annual
[2]May require capital expenditure of $25,000 per 1,000 acre operating unit for stubble mulch equipment.
[3]Excludes cost for managerial ability, risk and any additional cost to operators within multiple holdings.
[4]Production cost does not reflect additional cost to operator with multiple holdings.

Table 19. Effects Of Alternatives And Comparisons To Future Without

		Economic Development		Environmental Quality	Social Well-Being
	High Precipitation	Beneficial	Adverse	Beneficial & Adverse	Beneficial & Adverse
ALT #3	Maximum income alternative[5] 739,000 acres of wheat-peas with minimum tillage.	150.9	109.3	1. Predicted average annual sheet and rill erosion of 5.5 million tons per year. This is a reduction of 3.3 million tons; a 37% reduction. 2. Sediment yield to streams is predicted to be 1.6 million tons per year; a reduction of .9 million tons. 3. Wildlife habitat value of 3%. No change. 4. Number of Avian species expected, 12/100 ac. No change. 5. Use of 15 million gallons of fuel; increase of 1.8 million gallons. 6. Use of 37.5 million pounds of fertilizer; a decrease of 18.1 million pounds. 7. Increase use of insecticides and herbicides. 8. Risk of high erosion rates occurring increases if high residue management cannot be applied because of weather factors.	1. Production increases from future without to 25.9 million bushels of wheat; a 2.7 million bushel increase. 2. Price of peas and lentils would soon collapse under intense supply pressure. 3. In the short run, income would increase. 4. High residue management would be difficult to achieve for most operators. 5. Early seed emergence would be difficult to achieve. 6. Sensitivity to timeliness of operation increases sharply. 7. Increasing dependence on chemical weed control.
	The value to producers of outputs of goods and services.	150.9			
	The value of on-farm resources required.		109.3		
	Net effects.	41.6			
	Net effects compared to future without.	39.2			
ALT #4	Maximum erosion reduction[6]			1. Predicted average annual sheet and rill erosion rate of 2 tons per acre or 1.5 million tons per year; an 83% reduction. 2. Sediment yield to streams would be .4 million tons per year; a reduction of 2.1 million tons. 3. Wildlife habitat value would increase to 16% of optimum; an increase of 13%. 4. Number of Avian species increases to 21 species/100 ac; an increase of 9 species/100 ac. 5. Use of 13.3 million gallons of fuel; an increase of .1 million gallons. 6. Use of 51.8 million pounds of fertilizer; a decrease of 3.8 million pounds. 7. Decrease use of herbicides and insecticides.	1. Production of 19.2 million bushels of wheat; a reduction of 4 million bushels of wheat annually. 2. Average income decreases. 3. Risk of crop failure decreases. 4. Loss of acreage equivalent to about 275 farms. 5. 800 or more farms may be reduced to non-economic units. 6. Some economies of size will be lost. 7. Operators should be able to manage remaining acres at a higher level. 8. Opportunity for upland bird hunting would increase.
	233,000 acres of recrop winter wheat with minimum tillage and terraces, divided slopes or strips if a winter wheat-spring wheat system is used.	31.9	38.1		
	202,000 acres of wheat-barley-peas with minimum tillage, terraces and divided slopes.	32.7	30.6		
	83,000 acres of wheat-peas with minimum tillage, terraces, and divided slopes.	16.9	13.0		
	221,000 acres of grass that would be seeded on Class IV, Class VI, and adjacent Class III areas.		19.3		
	The value to producers of outputs of goods and services.	81.6			
	The value of on-farm resources required.		101.0		
	Net effects.		-19.4		
	Net effects compared to future without.		-21.8		

[5]Within the limitations of this study, this alternative is the Economic Development Plan.
[6]Within the limitations of this study, this alternative is the Environmental Quality Plan.

Table 20. Effects of Various Levels of Erosion Reduction on Cropland, Palouse River Basin

Effects	Units	Present	EROSION REDUCTION LEVEL					
			30%	40%	60%	70%	74% Maximum	50% Land Retirement
Erosion	Tons/Acre	14.5	10	8	5.5	4.4	3.8	7.3
Cropland								
Wheat	1,000 acres	598	485	653	736	736	736	449
Barley	1,000 acres	159	191	131	15	180	186	119
Peas/Lentils	1,000 acres	159	191	191	191	191	185	119
Fallow	1,000 acres	305	354	246	279	114	114	229
Grass/Trees	1,000 acres	0	0	0	0	0	0	305
Total	1,000 acres	1,221	1,221	1,221	1,221	1,221	1,221	1,221
Cropland Management								
w/o Minimum Tillage	1,000 acres	668	0	0	0	135	0	507
with Minimum Tillage	1,000 acres	546	1,221	1,221	1,221	1,086	1,221	409
Field Strips or Divided Slopes	1,000 acres	0	0	0	440	552	0	0
Terraces	1,000 acres	0	0	0	0	362	517	0
Field Strips or Divided Slopes and Terraces	1,000 acres	0	0	0	440	22	704	0
Gross Receipts	Million $'s	158	164	175	173	166	165	132
Cost of Production	Million $'s	61	58	69	72	78	82	45
Conservation Costs	Million $'s	0	0	0	4	5	10	4
Returns to Land, Labor, Capital, and Management	Million $'s	97	106	106	101	88	83	87
Wildlife Habitat Value								
All Land	% of Optimum	12	13	13	14	15	16	19
Cropland Only	% of Optimum	6	7	7	8	8	9	18
Avian Species								
All Land	No/100 acres	125	130	140	155	155	160	190
Cropland Only	No/100 acres	96	115	115	125	125	130	180
Highway and Road Ditch Maintanance Costs	$1,000	1,000	700	600	400	300	260	500

No-Till Analysis

No-till farming[1], which is actually very minimal tillage, may offer the greatest opportunity for erosion control in the Palouse River Basin. It is difficult to analyze because of the amount of variation between systems used. Results of field trials used in the region vary from outstanding to disastrous.

The no-till drill does not have any comparative advantage in operation efficiency. It takes just as much time to seed a field with one heavy 12' no-till drill as it does to perform normal tillage and seeding operations with conventional equipment.

With present technology, the most successful use has been in the high precipitation zone where no-till drills are used to seed winter wheat following minimum-till spring wheat. In this area, yields have been comparable or higher than conventional systems with no increase in production costs. Rodent problems sometimes have been serious with no-till farming.

In the low and medium precipitation area, where fallowing is required, weed control on no-till fields is often ineffective or prohibitively expensive. For chemical fallow, a herbicide bill of $30 to $50 per acre is not uncommon at the present time. Erosion rates are predicted to be less than 3 tons per acre on fields where no-till farming systems are used.

[1]For practice description, see page 80

Conclusions

1. Reduction in summerfallow acreage through increases in acreage in small grain crops can reduce erosion rates 50 percent in the high precipitation zone.
2. Changes in tillage methods (increased use of minimum tillage on annual grain crop rotations and stubble mulch on summerfallow land) can reduce erosion more than 40 percent in the low precipitation zone and 55 percent in the medium precipitation zone.
3. Returns can be increased through improved tillage methods which result in reduced costs and improved yields. Reductions in acreage of summerfallow can also result in increased returns.
4. As maximum levels of erosion reduction are achieved, returns will decrease.
5. Capital expenditures increase as farmers shift to different crops or to farming systems which require different equipment, and as additional conservation practices are applied to the land.
6. The retirement of highly erosive areas to grass, would result in an estimated 18 percent reduction in production and a 50 percent reduction in erosion. It would result in significant improvement in wildlife habitat and increases in wildlife population.
7. Terraces, divided slope farming and stripcropping systems will have to be applied to all cropland areas where they can be used if annual erosion rates are to be reduced to an average of 5 tons per acre if the level of management cannot be increased.
8. Conservation practices other than planting of additional cover will have little effect on wildlife.

Implementation

Alternative methods of reducing erosion and sediment, their effectiveness and costs, have been presented in this report. These alternatives can be used as decisions are made on what will be done to solve the problems of the basin. As water quality programs are developed and best management practices are selected, the alternatives can be used in evaluation of their potential impacts and effectiveness in reaching water quality goals. The major question remaining is what kind of an implementation program will be necessary to get these erosion control measures applied to the land. An implementation program for a 10-year period is presented here.

An effective information-education program must be one of the first steps to a successful implementation program. The program should include: demonstrations of farm equipment, farming techniques, and effects of farming operations in relation to erosion control. There should be direct contact between farmers and extension specialists. The program also should include farm tours, television and radio programs. All available, including new, information regarding conservation practices should be made available to the land user. It is estimated that a good information-education program will

cost $100,000 the first year and $50,000 for each remaining year of the 10-year period. (See Figure 11).

Additional technical assistance will be needed. Concentrated assistance in planning and application of conservation practices is an essential part of this proposal. As conservation technicians concentrate on working with individual farmers in getting conservation on the land, it will require more time per farmer assisted. If erosion rates are to be reduced by 30 percent, it is estimated that only 10-20 farmers could be assisted per man-year. If greater rates of erosion reduction are to be achieved, even more technical assistance will be needed. It is estimated that increased technical assistance will cost from $180,000 to $250,000 per year.

Additional field evaluation of conservation practices on specific sites is needed. The needed information can be acquired through continuing studies of conservation practices as they are applied to the land through field trials and interviews. Cost of gathering this data is estimated at $100,000 per year. Information needed in this assessment will remain constant, while the items evaluated will vary during the 10-year period.

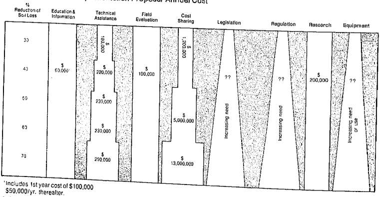
A cost-sharing program is needed for farmers who apply conservation practices. The amount of funds needed for cost-sharing will depend on levels of erosion reduction desired (e.g., to achieve a 30 percent reduction will cost less than a 70 percent reduction). It is estimated that $1.2 million will be needed for cost-sharing to achieve a 30-40 percent reduction in soil loss; $13 million will be needed if a 70 percent reduction is to be achieved.

Additional legislation and regulation needed probably will vary, depending on the success of the other implementation methods. If higher levels of erosion reduction are to be achieved, it is expected that increased legislative and regulatory action will be needed.

A redirection in research programs is needed. Research on development of new grain varieties should be directed towards types that can produce well, with no-till, minimum tillage, and stubble mulch tillage systems. New and improved tillage and seeding equipment is needed. Data is needed on the effects of conservation practices on crop yields. Cost of an expanded research effort to meet these needs is estimated at $200,000 per year.

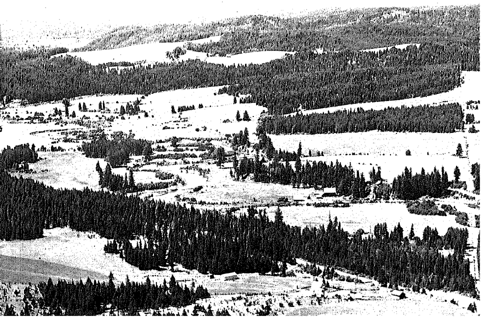
If erosion levels are to be achieved, many farmers will find it necessary to purchase implements that are less destructive than those they are presently using. With increasing amounts of erosion reduction, more and more farmers will have to change to different kinds of tillage implements. These changes will become an important part of the annual cost of this implementation program.

Figure 11 Palouse Implementation Proposal[2] Annual Cost



[1] Includes 1st year cost of $100,000 $50,000/yr. thereafter.
[2] 10-year program.

THE IDAHO PALOUSE



The Idaho Palouse

To achieve the purposes of this study, the entire Palouse River Basin has been addressed in other portions of this report. This section has been written to document the erosion and sedimentation rates from the Idaho portion of the basin and to present more detailed analysis of data regarding Idaho forested areas. This was done because of the need to present the data by state as well as hydrologic boundaries.

Nearly 17 percent—353,625 acres—of t Palouse Basin is in Idaho. Approximately percent of the total sediment yield from t basin originates in Idaho. Table 21 and 22 sh(total soil erosion and sediment delivery frc Idaho.

Table 21. Total Annual Soil Erosion—Palouse River Basin—Idaho—With Existing Land Use

Land Use[1]	Acres	Average Annual Soil Erosion (Tons)
Forest	162,597	70,594
Cropland	169,733	1,717,704
Pasture and Rangeland	17,112	25,500
Other Land	4,183	6,000
Total	353,625	1,819,794

[1]Includes stream channels in the four land use categories.

Table 22. Total Sediment Delivery—Palouse River Basin—Idaho—Existing Land Use

Land Use	Delivery Rate (percent)	Sedime!
Forest	13	
Cropland	29	
Pasture and Rangeland	25	
Other Land	25	
Stream Channels	90	
Total		

Cropland

Fourteen percent (170,000 acres) of the cropland in the basin is in Idaho. This land, the problems and alternative treatments have been described in other portions of this report. Specific recommendations have not been presented here, alternative cropping systems and conservation practices displayed in Chapter V are adaptable to these lands. Maps following pages 14, 34, and 52 are of particular interest in relation to data presented in this section. Erosion by soil association is presented and may be of use to the state as well as for basin wide analysis.

Table 23. Average Annual Soil Erosion From Cropland by Soil Association—Idaho Portion, Palouse River Basin

Soil Association	Acres	Avg. Annual Soil Erosion (tons/acre)	Total Annual Soil Erosion (tons)
Palouse-Thatuna	87,370	11	960,070
Palouse-Thatuna-Naff	23,000	12	276,000
Palouse-Thatuna-Tekoa	4,000	12	48,000
Larkin-Southwick	37,354	7	261,478
Freeman-Joel-Taney	10,517	12	126,204
Helmer	3,000	6	18,000
Santa-Carlington	4,492	6	26,952
Total	169,733		1,716,704

Average = 10 tons per acre per year

Forest Lands

Forest lands in the Idaho portion of the Palouse River Basin total 162,597 acres or about 8 percent of the entire river basin. These forest lands contribute about 41 percent of the mean annual stream flow of the entire basin, as measured near Hooper, Washington. Average erosion from these lands is about 70,594 tons per year. Approximately 13 percent, or 9,304 tons, of this erosion enters waterways as fluvial sediment.

Primary areas of erosion are the stream system and timber harvest. The principal source of sediment is the 139 miles of stream channel, with an average of 8,654 tons per year or 50 percent of the total sediment from forested lands of the Idaho basin.

Although 17,958 tons per year of sediment from these forest lands and stream channels is significant, it amounts to less than 1 percent of the annual sediment discharged by the Palouse River into the Snake River below Hooper, Washington.

Mean annual gross erosion from forested lands in Idaho is equivalent to 275 tons per square mile; sediment averages 70 tons per square mile per year. These rates are quite low compared with agricultural lands which are continuously disturbed by annual cropping. Table 24 summarizes gross erosion and sediment by forest land use.

Table 24. Gross Erosion and Sediment by Forest Land Use

Map Color	Land Use Type	%	Acres	Mean Erosion Rate T/Ac	S.D. Ratio Percent	Gross Erosion Tons/Year	Gross Sediment Tons/Year
Pink	High Elev CC	2	3,251	3.95	15	12,830.6	1,877.1
Yellow	High Roading	3	4,877	3.47	19	16,915.8	3,255.1
Red	Placer Mining	1	195	1.73	88	336.6	296.2
Dark Blue	High Elev PC	6	9,756	.82	14	7,990.5	1,080.3
Light Green	Low Elev PC	1	1,219	1.10	21	1,337.6	280.9
Olive	Meadow Flats	1	488	.77	10	376.2	37.6
Light Blue	High Elev SC	4	6,503	.57	23	3,727.6	843.7
Dark Green	Low Elev SC	22	36,357	.19	10	6,959.0	663.0
Orange	High Elev DC	42	69,058	.13	08	9,204.5	748.6
Purple	Low Elev DC	19	30,893	.06	11	1,806.1	200.9
	Stream Erosion		139 Mi.	65.5 Tons/Mi.	95	9,110.0	8,654.0
	TOTAL	100	162,597	GROSS TONS		70,594.5 Erosion	17,957.6 Sediment
				MEAN TONS/ACRE/YEAR		.43	.11
				GROSS SEDIMENT DELIVERY RATIO =		.25	

CC = Clearcut
PC = Partial Cut
SC = Sparse Cover
DC = Dense Cover
SD = Sediment Delivery

NOTE: Erosion rates are for average conditions and recognize the various stages of hydrologic recovery on road harvest areas, etc.

Management

Forest management in the Idaho Palouse varies, partly because of ownership (Table 25). About 94,000 acres, or 58 percent, of the basin is professionally managed. The remainder receives varying management depending upon owner interest. The Idaho State Department of Public Lands is actively involved in a farm forestry program directed to many of the owners of small, private woodlands which make up more than 68,000 acres in the basin.

In addition, the Soil Conservation Service and the conservation districts provide on-site land use planning assistance to private woodland owners.

Several silvicultural systems are used. Clearcutting and seed-tree systems are the common regeneration methods. Nearly all forests are under an even-aged management regime. Several intermediate cuts are used, including overwood removal, special selection cuts and salvage. Salvage of white pine diseased by blister rust, Douglas-fir and grand fir killed by tussock moth and other dead and diseased trees accounts for up to a third of the acreage logged during a year. Though the acreage cutover varies from year-to-year, it probably has averaged about 1,000 acres annually. During an "average" year, 300 acres would be clearcut, seed trees would be left on 110 acres, and various intermediate cuts would be performed on the remaining 590 acres.

Timber stand records and observations indicate approximately 4,000 acres—less than 3 percent—of all forest ownerships are inadequately stocked and in need of site preparation work.

Harvesting

Several logging systems are used in the Basin. Generally, tractors are used to skid logs on level ground and on slopes up to 30 to 40 percent. On steeper ground, cable systems are used, the most common being the Idaho "jammer". In jammer skidding, logs are dragged across the ground usually not more than 300 feet. Occasionally, tower height and topography enable one end of a log to be lifted. Parallel roads are necessary about every 350-400 feet.

Both systems result in a considerable ground disturbance for roads and skid trails. This disturbed ground—particularly roads built on steeper slopes—is susceptible to erosion and the source of some sediment reaching streams from forest lands.

There is a trend toward using logging systems that are less damaging to water quality. Systems capable of fully suspending logs for longer distances are beginning to be used. This permits longer distances between roads (over 1000 feet) and less soil disturbance between them. Implementation of the Forest Practices Act also tends to lessen soil erosion and sedimentation of streams. The Act prescribes practices which will minimize sedimentation of streams. The Act is administered by the Idaho State Department of Public Lands.
(See table 25)

Table 25. Land Ownership Idaho—Palouse Forest Land

Ownership	(approximate) Acres	Percent
Small Private	68,667	42
Industrial Forest	20,950	13
State of Idaho	19,430	12
Bureau of Land Management	260	—
National Forest	53,290	33

Vegetative Cover

The North and South Forks of the Palouse River Basin in Idaho contain 162,597 acres of forest land; of this, 2,411 acres are composed primarily of moderately wide, gently sloping depositional land along third and fourth order stream[1] bottoms. The remaining acreage is gently rolling to steep, deeply dissected land.

Following is a list of forest land areas differentiated according to vegetative ecosystems: [a]

	Plant Community	Acres	Percent
1.	Western redcedar, grand fir—pachistima Douglas-fir—ninebark and Ponderosa pine—wheatgrass	112,192	69
2.	Western hemlock—pachistima		
3.	Western redcedar, grand fir—pachistima Douglas-fir—ninebark		
4.	Grand fir—western redcedar—pachistima		
5.	Semi-wet meadow—ponderosa pine—Hawthorne		
	TOTAL ACRES		

[1]Horton-Strahler Stream Classification System. Where the smallest headwater streams are the first order. When two 1st order streams jo a second order strea

Stream Channel Stability

Forested lands within the study area contain 139 miles of perennial stream channel. Stability of this distribution system for the water resource of the Basin varies as follows: [b] (See table 26)

Table 26. Channel Erosion and Sediment Rates by Stability Class

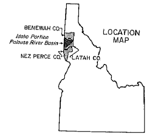
Channel Stability Class	Number Miles	Mean Erosion Rate Tons/Mile/Year	Gross Erosion Tons/Year	Gross Sediment Tons/Year*
Good	35	10	350	332
Fair	76	60	4,560	4,332
Poor	28	150	4,200	3,990
TOTAL	139		9,110	8,654*

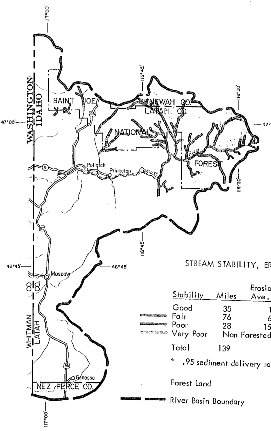
*.95 sediment delivery ratio.

There is a proven relationship between stream channel stability, erosion, and resulting offsite sedimentation [c]. This is a dynamic process which depends on volume of stream flow. Channel erosion potential and sediment rates also vary by land form. In the North Fork of the Palouse, higher erosion rates occur on depositional land forms, such as valley bottoms where many stream banks have fine textured soils and tree roots and rocks are lacking. The high rate of stream bank erosion in these areas often has been accelerated by cattle trampling the soil.

From the gross erosion standpoint, the erosion from stream channels on forest lands in the Idaho Palouse Basin is low and comprises only 13 percent of the total erosion from forest lands. However, from the gross sediment standpoint, the fluvial sediment from stream channels is high, comprising 48 percent of the gross sediment derived from forested lands in the Idaho Palouse Basin.

Placer mining for gold in the North Fork of the Palouse River headwaters caused severe channel scouring and stream bank vegetation loss on four miles of third order stream channel. Since most of the fine textured materials have since eroded, suspended sediment loads from the area are currently low. However, lack of channel stabilization does result in high bedload concentrations during annual peak discharge.





STREAM STABILITY, EROSION AND SEDIMENTATION

Stability	Miles	Erosion Rate Ave. Tons/Mile	Gross Erosion Tons/Year	Gross Sediment Tons/Year
Good	35	10	350	332
Fair	76	60	4,560	4332
Poor	28	150	4,200	3990
Very Poor	Non Forested Lands			
Total	139		9,110	8654*

* .95 sediment delivery ratio-forested lands only.

Forest Land

River Basin Boundary

FOREST LAND
STREAM STABILITY, EROSION AND SEDIMENTATION

IDAHO PORTION

PALOUSE RIVER BASIN

IDAHO AND WASHINGTON

JANUARY 1977

5 0 5 10 MILES

SCALE 1:500,000

Source:
Base map prepared by SCS, WTSC Carto Unit from state staff compilation.
Thematic detail compiled by USFS, S&PF, Region 6 from survey based on USFS April 1975 stream survey procedure, publication number R1-75-002.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-OL-23732-4

Climate

Following are average air temperatures in Idaho forest lands of the North Fork of the Palouse Basin [d].
(See table 27)

Table 27. Average Air Temperatures—Idaho Forest Lands

Elevation		Annual Average	January Average	July Average
Low Elevation	2500'	47.4°F	30.1°F	66.3°F
High Elevation	2500'	42.0°F	27.4°F	58.2°F

Change of air temperature decreases 2.5°F for each 1,000 foot rise in elevation. In mountain canyons, however, cold air drainage is often blocked, leaving localized cold air pockets which can produce frost conditions. Air temperature is a primary cause of short growing seasons, which make these forest lands unsuited for agricultural crops.

Mean annual precipitation on Idaho Palouse forest lands range from 25 inches at the lower elevation to 50 inches along the high peaks and ridges. Generally, there is a seven inch increase in mean annual precipitation with each 1,000 foot rise in elevation [e]. However, geographic conditions strongly affect local precipitation, particularly in snow country. (Table 28)

Snow normally comprises 40 percent of the annual precipitation at the lower forest land elevations. It contributes 60—70 percent of the total annual precipitation at higher levels.

Precipitation Intensity—The following are the approximate storm frequencies for the forest lands within the North Fork of the Palouse River [g].

Return Frequency (Years)	Duration	Amount (Inches)
10	30 min.	.6
25	30 min.	.6
50	30 min.	.7
10	1 hour	.7
25	1 hour	.8
50	1 hour	.9
10	24 hour	2.25
25	24 hour	2.6
50	24 hour	3.0

Table 28. Annual Palouse River Basin—Idaho Forests Precipitation Occurance[f]

Month	Percent of Annual Precip.	Month	Percent of Annual Precip.
January	12.0	July	1.8
February	9.6	August	2.1
March	9.5	September	4.5
April	7.6	October	9.0
May	6.1	November	13.2
June	8.4	December	16.2

Water Yield

Mean annual water yield from forested lands along the North Fork of the Palouse River ranges from 5 to 30 acre inches per year. Annual stream flow is about 178,856 acre feet[h]. This stream flow amounts to about 1.1 foot per year per acre, which is equal to about 83 percent of the mean annual flow of the Palouse River at Colfax, Washington and 41 percent of the mean annual Palouse River discharge at Hooper, Washington[i,j].

Figure 12 Forest Land
North Fork Palouse River

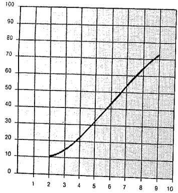


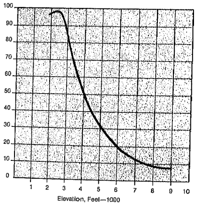
Figure 12 shows the relationship between mean annual runoff and elevation for the forested lands of the North Fork Palouse River in Idaho. The regression is based on the best available information using Thornwaite's water balance computer model.

Where: $RO = P - ET$
When:

RO = Annual Runoff
P = Annual Precipitation
ET = Annual Evapo-Transpiration loss

There have been minor increases in water yield from forested acres recently converted to agriculture. Water yield also has increased on about 5,000 acres of forest land as a result of timber harvest activities. Generally, areas are so dispersed and hydrologic recovery so fast that total increase in water yield from forest lands, under present management, amounts to less than 1,800 acre feet per year. This represents only a 1 percent increase (Figure 13). Uncontrolled timber harvest could increase the water yield and change the water quality situation dramatically from its present condition.

Figure 13 Estimated Water Yield Increase* for the initial year of treatment as percent of normal annual runoff by elevation for the Clearwater National Forest



* Based on: $\frac{\text{Transpiration (present)}}{\text{Runoff (present)}} \times 100$ (for clearcut treatment)

Compared to other forested watersheds in North Idaho, the North Fork Palouse Basin produces relatively little water primarily because there are no extensive areas of high country which receive great amounts of precipitation[1]. However, in terms of the entire Palouse River Basin, the forest land water yield from Idaho is extremely significant.

[1]White Pine Planning Unit Multiple Use Plan 1975, Final Environmental Impact Statement, U.S. Forest Service.

Figure 14 Average Discharge—1000 CFS
Palouse River, Potletch, Idaho 1966-1972

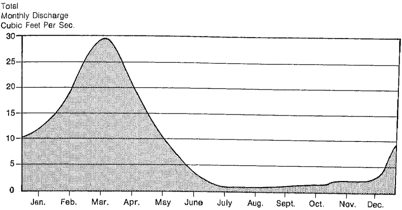
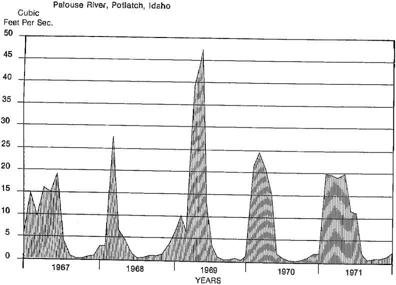


Figure 14 depicts the annual discharge distribution and fluctuation of the Palouse River at Potlatch, Idaho. Normally, the peak flow occurs in late March to April. The early peak discharge occurs largely because of the lower elevation and warm, south-facing slopes on which snow melts early.

Flooding

Annual stream flows in forested lands of the North and South Forks of the Palouse River fluctuate extremely (Figure 15). The flood plain of forested land is small because, normally, stream channels are deeply incised. However, this is frequently complicated by the natural and people-caused debris and log jams which restrict high flows. Floods occur periodically in small communities which are on depositional lands, particularly following rain or snow in late December through February.

Figure 15 Total Monthly Discharge—1000 CFS Palouse River, Potlatch, Idaho



The flow of the North Fork Palouse River at Potlatch varies greatly from year-to-year and within the year[1]. For example, in water year 1973 the following flows were observed and compared with the record event (USGS Station # 13345).

Time	Parameter	Instantaneous Discharge Amount	Date
Water Year 1973	Minimum Flow	.07 CFS	Sept. 24, 1973
Water Year 1973	Mean Flow	96.70 CFS	
Water Year 1973	Maximum Flow	1850 CFS	Dec. 22, 1973
11-year Record	Minimum Flow	.07 CFS	Sept. 24, 1973
11-year Record	Maximum Flow	6100 CFS	Jan. 21, 1972

[1]Surface Water Supply of the United States, 1950-1975. WSP #2134, Part 13 Snake River Basin, U.S. Geological Survey.

Erosion

Erosion rates on forest lands of the North Fork Palouse River in Idaho are based on identification of land types: groups of land having similar vegetation patterns, soil types, slope hydrology, bedrock type and structure, and geomorphic processes. These land types were correlated with land form and present land use to arrive at 10 distinct erosion contribution areas. Erosion rates are based on research data, field examinations, aerial photo interpretations, and field plots. See erosion-sediment map (following page 118) for site locations.
(See table 29)

The channel system contributes only 13 percent of the mean annual erosion but has the highest sediment delivery rate.

Table 29. Mean Annual Erosion, Idaho Forest Lands

Map Color	% of Area	Acres	Mean Erosion Rate Tons/Acre/Year	Gross Erosion Tons/Year
Pink	2	3,251	3.95	12,830.6
Yellow	3	4,877	3.47	16,915.8
Red	1	195	1.73	336.6
Dark blue	6	9,756	.82	7,990.5
Light green	1	1,219	1.10	1,337.6
Olive	1	488	.77	376.2
Light blue	4	6,503	.57	3,727.6
Dark green	22	36,357	.19	6,959.0
Orange	42	69,058	.13	9,204.5
Purple	19	30,893	.06	1,806.1
Channel Erosion		139 miles	65.5 Tons/Mile	9,110.0
TOTAL	100%	162,597 Acres		70,594.5 Tons
Weighted mean erosion rate = .43 Tons/Acre/Year = 275 Tons/Sq. Mile				

Sediment

Approximately 25 percent of the mean annual erosion ends up in the stream system as fluvial sediment and is accounted for as follows:

Table 30. Gross Sediment Delivery—Idaho Forest Areas

Map Color	% of Area	Acres	Sediment Delivery Ratio—Percent	Gross Sediment Tons Per Year
Pink	2	3,251	15	1,877.1
Yellow	3	4,877	19	3,255.1
Red	1	195	88	296.2
Dark blue	6	9,756	09	1,080.3
Light Green	1	1,219	21	280.9
Olive	1	488	10	37.6
Light blue	4	6,503	23	843.7
Dark Green	22	36,357	10	683.0
Orange	42	69,058	08	748.8
Purple	19	30,893	11	200.9
Stream Channels		139 miles	95	8,654.0
TOTAL	100%	162,597 Acres		17,957.6 Tons

Weighted mean sediment rate = .11 Tons/Acre/Year = 70 Tons/Sq. Mile

Although the forest stream channels contribute only 13 percent of the gross erosion from forested lands, they do contribute 48 percent of the gross sediment. The 8,654 tons per year of channel sediment, though substantial, is much less than for typical streams on agricultural land. This channel sediment averages 62.26 tons per mile per year. Fifty percent of the gross mean annual sediment from the channel system on forest land moves as bedload sediment, rather than as suspended sediment; primarily because of steep channel gradient, material size and shape.

The following table shows comparative amounts of sediment from the Idaho Palouse forest land—162,597 acres—and the total sediment from all of the Palouse Basin: 2.1 million acres. Idaho forest lands thus comprise about 8 percent of the Palouse River Basin. The table below contains mean annual data and is based on USGS Water Supply Paper #1899C'.

Table 31. Idaho Forests and Palouse River Basin

	Mean Annual Sediment—Tons	Mean Annual Sediment—Tons Per Square Mile
Forest Lands Idaho	17,957	70
Palouse River @ Colfax	360,000	730
Palouse River @ Mouth	1,580,000	480

The above data indicates that forested lands in Idaho contribute only one percent of the mean annual sediment yield of the Palouse River at its confluence with the Snake River. They also have the lowest mean annual sediment rate per square mile—only 10 percent of the sediment yield of the Palouse River at Colfax, Washington.

Bedload Component of Gross Sediment

The clearwater National Forest hydrologist has measured suspended sediment and bedload at three forested subwatersheds in the North Fork of the Palouse River. They are Disalto Creek, Wagner Gulch, and Stephens Creek.

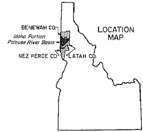
In 1975, gross sediment from these watersheds ranged from .03 to .08 tons per acre per year. Bedload sediment ranged from 11 to 76 percent and averaged 50 percent. Bedload makes up a high percent of the sediment in streams containing small, rounded gravels, with a steep channel gradient. The transport distance of bedload is much less than the suspended sediment. Bedload normally settles to the channel bottom at its first encounter with a low gradient depositional land form. Frequently bedload causes channel blockage in the low gradient valley streams which in turn causes accumulated bank scouring to the valley (fine texture) streambanks.

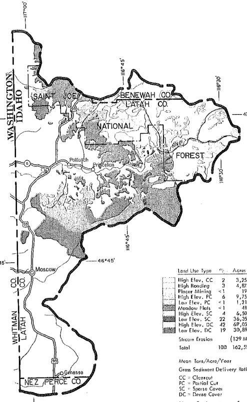
[1]Sediment Transport by Streams in the Palouse River Basin, Washington and Idaho, 1961-1965, Water Supply Paper 1899C, U.S. Geologic Survey.

Table 32. General Description of Past Land Use and Cover Within Erosion Map Units

MAP REFERENCE COLOR	GENERAL DESCRIPTION
Pink	This area is roaded, in the higher elevations, generally on SW aspects which have been clearcut—steep, high runoff areas.
Yellow	These areas have an unusually high density of roads on steep slopes with high precipitation and runoff rates.
Red	This depositional land type has been severely scoured during early-day gold placer mining.
Dark blue	These areas are at higher elevations and have been partial cut at various intensities.
Light green	These areas are at the lower elevations and have been partial cut at various intensities.
Olive	These are wide, alluvial, forested meadow lands, often grazed and contain scoured streambanks. Soils are low in rock content along streambanks.
Light blue	There are high elevation areas containing relatively sparse forest due to soil aspect.
Dark green	These areas are at the lower elevations and have sparse forest cover due to soil, aspect, and precipitation conditions.
Orange	These areas are at the higher elevations and contain dense forest cover.
Purple	These areas are at the lower elevations and have predominantly dense forest cover due to available moisture.

MAP REFERENCE COLOR GENERAL DESCRIPTION





EROSION AND SEDIMENT YIELDS

Land Use Type	%	Acres	Mean Erosion Rate T/Ac.	S.D. Ratio Percent	Gross Erosion Tons/Year	Gross Sediment Tons/Year
High Elev. CC	2	3,251	3.95	15	12,830.6	1,877.1
High Roading	3	4,877	3.47	19	16,915.8	3,255.1
Placer Mining	<1	195	1.73	88	336.6	296.2
High Elev. PC	6	9,756	.82	14	7,990.5	1,080.3
Low Elev. PC	<1	1,219	1.10	21	1,337.6	280.9
Meadow Flats	<1	488	.77	10	376.2	37.6
High Elev. SC	4	6,503	.57	23	3,727.6	843.7
Low Elev. SC	22	36,357	.19	10	6,959.0	683.0
High Elev. DC	42	69,058	.13	08	9,204.5	748.8
Low Elev. DC	19	30,893	.06	11	1,806.1	200.9
Stream Erosion		(139 Mi.)	(65.5 Tons/Mi.)	(95)	9,110.0	8,654.0
Total	100	162,597			70,594.5 Erosion	17,957.6 Sediment
Mean Tons/Acre/Year					.43	.11

Gross Sediment Delivery Ratio = .25

CC = Clearcut
PC = Partial Cut
SC = Sparse Cover
DC = Dense Cover

Note: Erosion rates are for average conditions and reco[illegible] the various stages of hydrologic recovery on road harvest ar[illegible]

Unit Boundary

River Basin Bo[illegible]

EROS

Water Quality

Weter quality, a relative term, has real meaning only when applied to a specific use of water. Table 33 is a summary of water quality data collected from selected forested tributaries to the North Fork of the Palouse River in July, 1974. It demonstrates the relatively high quality water from forest lands.

Table 33. Water Quality Data—Palouse River Basin Idaho Forest Streams

Station Locations / Parameters	Jerome Cr.	Strychnine Cr.	Bonami Cr.	Palouse R.	Palouse R.	Graves Cr.	Wagner Gu.	N. F. Palouse R.	Eldorado	N. F. Palouse R.	W. Pine Cr.	Disalto Cr.	Secuda Cr.	Flat Cr.
Conductivity Mmos/cm	42	25	35	35	55	40	88	32	17	25	26	28	40	65
Water Temp. °F	52	54	52	59	54	50	59	52	46	50	52	46	48	59
Hardness Mg/l	20	10	10	15	15	10	30	10	10	20	10	10	10	10
Nitrates Mg/l	12	14	14	4	6	8	9	3	8	7	6	10	5	3
Nitrites Mg/l	.008	0	.01	0	.1	.1	.1	0	.04	.01	0	0	.002	0
Phosphates Mg/l	4	.7	.1	.1	.45	.1	.05	.8	.4	.1	.1	3.2	.1	.15
Chlorides Mg/l	5	5	5	5	5	2.5	10	5	5	5	5	15	5	5
Sulfates Mg/l	8	3	0	0	2.5	5	0	0	2	1	8	3	8	10
Dissolved Oxygen % Mg/l	7	9	9	8	—	—	—	—	—	—	—	10	9	9
Dissolved Oxygen % Saturation	72	91	90	87	—	—	—	—	—	—	—	92	86	98
pH	6.3	6.4	6.4	6.4	6.5	6.4	6.5	6.4	6.8	6.3	6.5	6.2	6.7	8.4
Iron ppm	—	—	—	—	—	—	.1	—	—	—	—	—	—	—
Total Dis. Solids Mg/l	34	20	29	29	44	33	72	26	14	20	21	23	33	53

Water Quality Data—Bovill-Palouse Planning Unit—July 1974
Source: Clearweter National Forest

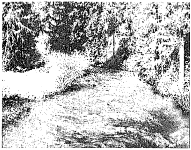
The water quality data in Table 34 is from U.S. Geologic Survey records and portrays the change in water quality as flows approach the Snake River.

Table 34. Comparative Water Quality Analysis

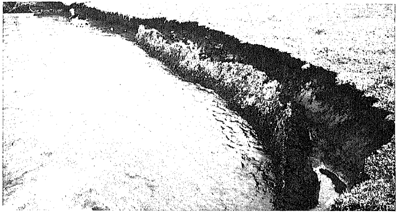
Parameter	North Fork Palouse at Potlatch, ID.	Lower Palouse at Hooper, WA.
Sample Date	9-23-74	9-16-74
Stream Flow (CFS)	6.6	54.0
Dissolved Sodium (PPM)	5.8	26.0
Dissolved Potassium (PPM)	1.9	4.7
Alkalinity (PPM)	39.	173.
Dissolved Sulfate (PPM)	3.7	14.0
Dissolved Chloride (PPM)	1.4	9.4
Nitrite & Nitrate (PPM)	.13	.87
Total Phosphorus (PPM)	.20	.25
Hardness (PPM)	32.	150.
Specific Conductance (micro mho)	78.	390.
Field pH (Units)	7.4	8.4

PPM = Parts Per Million—a measure of concentration.

Source USGS, September 1974



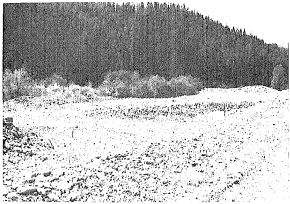
Typical forest land stream channel having "good" stability despite the steep sloping ground on the right side.



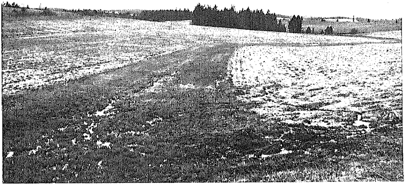
Typical alluvial valley depositional land form being used for pasture. The channel bank stability at this point is "very poor" due to the lack of bank rock content and brush root wads.

Road encroachment on stream system causes stream bank erosion and increases sediment delivery rate from road surface.

Encroachment of agriculture cropping practices to the edge of the stream system increases bank erosion and removes the sediment filter bed of grass and brush.

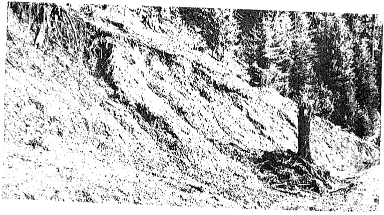


Remains of early day gold mining. Typical of red area on erosion-sediment map. (following page 126)

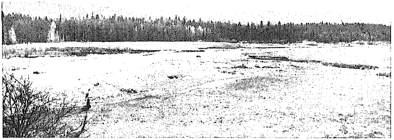


Forest land is typical of derk green colored areas on erosion-sediment map. Note inter-mingled agriculture lands and effective use of grassed waterway in foreground.

Temporary road with erosion evident. Located in Douglas-fir ninebark habitat type typical of the light blue area on erosion map.

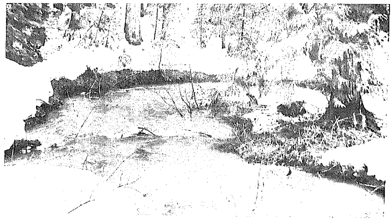


...ughing during spring runoff. Note ditch sedimentation. Typical of yellow area on erosion-sediment map.

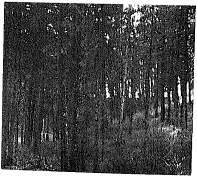


Forested meadow and meadow depositional land type. Note scoured stream banks of pasture land, flood damage and attempt to correct problem. Rip-rap material too small.

This area is typical of olive colored area on erosion-sediment map. Flooding of forested meadow land during April 1976. Unsurfaced roads along major streams have a high sediment delivery ratio.



Western redcedar pachistima habitat type—typical of the orange colored erosion-sediment map area. Note good stream channel stability even at high runoff.



Ponderosa pine-wheatgrass habitat type typical of the purple map colored areas.

Literature Cited:

[a]Idaho-Washington RC&D Project. May 1974, U.S. Dept. of Agriculture pp 23-31.

[b]Stream Channel Stability Evaluation. 1975, Northern Region, Hydrologist U.S. Forest Service.

[c]Hydrology of Northeast Washington. 1975, Clif Benoit, Colville, National Forest, U.S. Forest Service.

[d]Climatological Handbook—Columbia Basin States. September 1969, Meterology Committee, Pacific Northwest River Basins Commission.

[e]Water Yield Maps for Idaho. March 1968, Marvin Rosa, Agricultural Research Service publication #41-141, U.S. Dept. of Agriculture.

[f]Unpublished Hydrologic Data. August 1976, Melvin Bennett, Hydrologist, U.S. Forest Service, Orofino, Idaho.

[g]Climatological Handbook—Columbia Basin States. September 1969, Meterology Committee, Pacific Northwest River Basins Commission.

[h]Water Yield Maps for Idaho. March 1968, Marvin Rosa, Agricultural Research Service Publication #41-141, U.S. Dept. of Agriculture.

[i]Surface Water Supply of the United States, 1950-1975. WSP #2134, Part 13 Snake River Basin, U.S. Geological Survey.

[j]U.S. Geological Survey Water Quality Data. 1972-1974 Stream Gage #13345000 (Palouse River near Potlatch, Idaho).

AGENCY ACTIVITIES

Agency Activities

Soil Conservation Service

SCS became active in the Palouse River Basin in 1935, five years before the first conservation districts in the area were organized. Major SCS activities have included technical assistance to individual farmers and groups of farmers planning and applying conservation on the land through Soil and Water Conservation Districts. This extensive assistance is available to all farmers in the basin.

Soil surveys have been completed for the entire basin and reports have been published for Adams and Spokane Counties. The Latah County, Idaho soil survey is completed. The Whitman County survey is being prepared for publication.

All of the Idaho Basin and Spokane County is within the Idaho-Washington Resource Conservation and Development project.

SCS also assists the Agricultural Stabilization & Conservation Service with the technical aspects of conservation practice cost-sharing programs, including site inspection, before practice installation and followup inspection of completed practices.

Small Watershed Project (PL-566). The potential in the Palouse Basin for a small watershed project is expected to be high. The number of conventional projects involving channel work and major structures for flood control is limited. Instead, the anticipated PL-566 projects would involve installation of small conservation measures throughout community watersheds. The measures would include terraces, diversions, grassed waterways, debris basin, stripcropping, and grade stabilization structures.

Installation of recommended conservation measures would have a significant effect on erosion, sedimentation, and water quality within a watershed area. Presently, much of the conservation work is being installed on a piecemeal basis. If an overall plan could be developed over a larger area, a more orderly, integrated and efficient system could be installed.

Under the PL-566 program, combinations of measures would be analyzed and sponsors would select a recommended plan of action. Through the small watershed program, SCS would then assist with technical and possible financial assistance, if money was not available through other programs.

RC & D Potential for the Basin. Where basin areas are now within the RC & D area (Latah County, Idaho and Spokane County, Washington) SCS can accelerate technical and financial assistance. Measures would include critical erosion area, flood prevention, farm irrigation, land drainage, soil and water management for agricultural pollution, water-based fish and wildlife recreation developments for public use, and water quality management. Accelerated planning also is available for forestry measures and practices.

Conservation Districts

Legal subdivisions of state government Disticts coordinate soil and water conservation programs within their jurisdictions.

In the Palouse River Basin, there are county-wide conservation districts in all but Whitman County, which is served by four separate conservation districts.

Conservation districts focus particularly on severe erosion problems. They provide necessary local leadership to work with conservation planning and application. SCS provides a major part of its technical assistance through conservation districts.

Approximately 700 farmers are cooperators with basin Conservation Districts. With SCS technical assistance, these farmers have developed 400 conservation plans on over 700,000 acres of basin farmland.

Although SCS assistance is provided to farmers in applying numerous conservation practices, some are more commonly used in the area. Following is a listing of some of these practices which had been applied as of September 30, 1977 in Whitman County.

Pond (Number)	210
Grassed Waterway or Outlet (acres)	12,895
Minimum Tillage (acres)	44,196
Stripcropping (acres)	46,292
Terraces (feet)	31,537
Subsurface Drain (feet)	5,980,429

Conservation districts also are involved in educating people of the basin about conservation needs of the area. Effects of these efforts

have not been readily apparent under past voluntary programs. The broad impact of this is being recognized, as districts cooperate in development of county water quality plans.

In the future, districts should play an even stronger role in basin conservation activities. New state and national laws have given districts greater authority and responsibility. The Federal Water Pollution Control Act has played a major role in strenghening the mission of districts. As districts work to meet guidelines of this act, people are increasingly motivated to use the assistance districts can provide. As best management practices are applied to the land, district leaders believe people will continue to seek leadership from their local conservation district. The most effective incentives possible will be needed to get conservation on the land. Districts are arousing concern about keeping water quality planning for nonpoint pollution control at the local level. As the energy crisis intensifies, districts will become more involved in increasing public awareness of resource problems and the need to solve them through conservation measures.

Department of Ecology, State of Washington

DOE is responsible for planning, management and regulation for water and related land resources of the state. DOE coordinates federal and state grants for planning and construction. Floodwater damage, shoreline management, coastal zone management, water quality and water rights are among their resource management responsibilities.

DOE has played a major role in initiating action, obtaining funds, and giving coordination and leadership for water quality planning in the Washington portion of the basin. The department works through the State Conservation Commission, local conservation districts and water quality committees on development of best management practices to meet national water quality guidelines. DOE is expected to continue playing a significant role as best management practices are applied to basin land.

The Washington State Conservation Commission

An agency of state government, the commission administers legal and program activities of the 52 conservation districts located in Washington's 39 counties.

The Commission's functions are described under Chapter 89.08 RCW. The Conservation Commission is housed in and attached to the Department of Ecology (DOE) for administrative and fiscal purposes. Program operation is independent and guided by policy developed by the Commission members.

A brief list of activities may better illustrate the Conservation Commission's role relative to other conservation agencies:

1. The Conservation Commission has contracted with the DOE to develop an implemental plan for water quality improvement in dryland agriculture.
2. The commission has personnel in the field to assist individual conservation districts in program development, specific problems, and specific projects related to natural renewable resources.
3. The commission sponsors and conducts training conferences, e.g.:
   a. To acquaint conservation district supervisors with duties, responsibilities, and opportunities.
   b. To explain and implement uniform accounting procedures with conservation districts.
   c. To give motivational training.
4. The commission is responsible to see that supervisor elections are conducted and appoints two of the local five-member board of supervisors in each district.
5. The commission conducts regular meetings throughout the state, focused on understanding the complexproblems and opportunities of Washington's natural renewable resources. Periodic commission/conservation district board interaction around the state is carried out to allow a better mutual understanding of priority resource problems and opportunities.
6. The commission develops job descriptions, recruitment, and training programs for district employees.
7. The commission interacts and coordinates programs with the federal and state natural resource agencies.

Forest Service

The role of the Forest Service in the Palouse Basin includes administration of the national Forest System, cooperative State Forestry programs, and assistance to private forest owners.

Basin National Forest lands are managed by the District Ranger of the Palouse Ranger District as part of the Clearwater National Forest. Forest land in the Palouse Ranger District is managed for a variety of uses, forest products and services.

The Clearwater National Forest is currently updating management plans to reflect needs determined under the Forest and Rangeland Renewable Resources Planning Act Assessment, and planning requirement of the national Forest Management Act of 1976 (PL-94-588) which amends it.

The Forest Service state and private forestry mission is directed toward the following goals:

- to meet future demands for forest resources
- to extend available supplies and services
- to efficiently plan uses of land and water resources
- to apply research
- to maintain and enhance the environment

A variety of programs are designed to achieve these goals: improved harvesting and marketing of forest products; fire prevention and control, and reduction of losses from insects and diseases. Principal coordinating partner is the Idaho State Forester who— through cooperative agreements— provides technical assistance to private forest owners. The state forester also participates with the Forest Service in the insect and disease management program.

The Forest Service, in partnership with the state forester, also gives private forest owners technical assistance through the Resource Conservation and Development Program (RC&D). The RC&D Program is developed by local residents of the area, acting as sponsors.

Cooperative forestry programs probably afford small private woodland owners the best opportunity for improving forest management and water quality while increasing forest productivity. RC&D, in particular, is a delivery system with potential that far exceeds recent funding levels.

Department of Lands, State of Idaho

The State of Idaho has an active program on the 67 percent of the forest land in State or private ownership. This program includes responsibilities for timber management, grazing, and minerals on State land, cooperative services in timber management and fire protection on private lands. The Department of lands administers the State's fire hazard reduction program with about six to eight positions in the Palouse Basin. These same people serve as an initial attack force under the cooperative fire program. The Department also administers the State's interests in navigable streams.

Economics, Statistics and Cooperatives Service

ESCS conducts national and regional research, planning, and technical consultation. Other ESCS services relate to economic and institutional factors and policy on use, conservation, development, management, and control of natural resources. This includes determining the extent, geographic distribution, productivity, quality, and contribution of natural resources to regional and national economic activity and growth. ESCS studies resource requirements, development potentials, and resource investment economics; impacts of technology and economics on use of natural resources; resource income distribution and valuation; and recreational use of resources. The agency participates in departmental and interagency efforts to formulate policies, plans, and programs for the use, preservation, and development of natural resources.

The Cooperative Extension Service

CES has long been active in reduction of sediment and erosion. During the mid-1930's, extension agents helped the Soil Conservation Service select farms for demonstration and testing of conservation programs throughout the basin.

Local county extension agents assisted local farmers in formation of Conservation Districts under State Enabling Acts, passed in Washington and Idaho in the late 1930's. After districts organized, county agents were involved in arrangements for election of district supervisors,

formulation of district programs and work plans, arranging district annual meetings and assisting in district information and education activities. In 1944, county agents assisted in organizing Washington's first district association in Whitman County. They also helped with district newsletters. In the 1950's, an extension specialist was assigned to work with districts in Whitman county.

The Cooperative Extension Service has established numerous field trials and demonstrations of how to control weeds without increasing erosion hazards on cropland. Field trials and demonstrations have been broadened in recent years to include work on no-till farming systems.

Recent federal legislation related to Public Law 92-500 gave the CES a major role in erosion and sedimentation control by cooperating with conservation districts in non-point pollution control programs. The CES, through local agents, is cooperating with the SCS in assisting with planning and implementation of Section 208 of Public Law 92-500. CES helps organize County public awareness programs and works with county water quality committees. These water quality committees were organized to encourage citizen input into county plans for reducing and eventually controlling non-point sources of water pollution.

The Agricultural Stabilization & Conservation Service

ASCS, through the Agricultural Conservation Program, cost-shares with landowners and operators the installation of selected conservation practices on agricultural land. These practices include those which contribute to the conservation and development of soil, water, plant, wildlife, and other resources, as well as practices which help to reduce or control erosion, and chemical or animal-waste pollutants. This cost-sharing program is available to individual farmers and ranchers and to groups of landowners who have common problems too large or complex to be handled individually. ACP also cost-shares in the installation of emergency conservation practices following a natural disaster. The Soil Conservation Service is responsible for providing technical assistance for this program.

The Agricultural Stabilization and Conservation Service administers the USDA Agriculture Farm Program, relating to agriculture production control. ASCS administers the Agriculture Commodity Storage and Loan Program, and long-term cost-share agreements and contracts, utilizing State and County Committees established under Section 8(b) of the Soil Conservation and Domestic Allotment Act, as amended.

Science and Education Administration, Federal Research

SEA conducts research to find better ways of storing, saving, transporting, and using water. SEA researches both physical requirements and effects of soil and water conservation. This research is oriented primarily toward scientific determination of the effectiveness and feasibility of conservation practices: water management, including requirements and consumptive use of agricultural crops; sediment yield and delivery rates; conservation cropping systems and residue management, and hydraulic characteristics of surface methods of irrigation.

ARS has provided extensive assistance to development of basin data for the Universal Soil Loss Equation, which has been used extensively in this study. Continued work is needed with the USLE to improve and refine this valuable tool. As improved land management systems are applied to the land, SEA can assist in studying the effects of these systems. SEA can also play a key role in testing and developing improved tillage equipment—such as the no-till drill—which are needed to solve area erosion problems. Research is needed also on tillage erosion problems.

The Farmers Home Administration

FmHA makes water development and soil conservation loans to eligible individual farmers, rural residents, groups of farmers and rural communities. These loans are for developing water supply systems for domestic, livestock, and irrigation use; and for carrying out soil conservation practices. Each loan is scheduled for repayment according to the borrower's ability to repay, over a period of not more than 40 years. Loans also are made to local organizations to help finance projects and develop land and water resources in watershed planned under authority of Public Law 83-566. Eligible local organizations include flood con-

trol districts, irrigation districts, drainage districts, and similar legal entities which have authority under state law to construct, maintain, and operate works of improvement. These watershed loans are repayable over periods of up to 50 years.

The major purposes of FmHA's rural credit programs are:

1. To help build the family farm system, the economic and social base of many rural communities.
2. To expand business and industry, increase income and employment, and control or abate pollution.
3. To install water and waste disposal systems and other community facilities that will help rural areas upgrade the quality of living and promote economic development and growth.
4. To provide or improve modest homes in suitable rural environments at prices and on terms that families of low or moderate incomes can afford.

The University of Idaho and Washington State University

These two institutions of higher learning have contributed in three major ways to the job of controlling soil erosion in the Palouse River Basin: conducting basic and applied research related to various aspects of erosion control; educating and training students in agricultural disciplines related to soil conservation (thus making technicians available to the Soil Conservation Service, Extension Service, Science and Education Administration and other agencies which directly assist farmers in erosion control) and educating and training people who later become farmers in the Palouse Basin.

A specific example of research which aided soil conservation was development of Gaines wheat. Prior to development of Gaines by USDA and University plant breeders in the early 1960's, wheat varieties then in use produced extra long, heavy straw which lodged badly on some sites. This made residue utilization difficult or impossible with equipment then available. As a result, many farmers burned the straw after harvest. The new semi-dwarf variety Gaines and its successors produce a short, stiff straw and yield more grain per ton of residue than earlier varieties. A farmer is now able to better utilize grain residues for erosion control. Wheat breeders are currently working to develop better spring wheat varieties; winter wheats which thrive in rough seedbeds, and other soil erosion control improvements.

Research programs at the Universities have improved weed control methods compatible with erosion control needs. To a lesser degree, the institutions have worked on improved tillage methods for soil and water conservation.

Washington State University assists local Conservation Districts in the Washington portion of the basin in yet another way. In 1953, a number of Districts began helping cooperating farmers with moisture-nitrogen testing of soils to guide fertilizing practices. The University has assisted with this job. WSU provides technical direction for lab operation by: training District lab technicians; calibrating lab equipment; providing technical formulae for making tests and interpreting results, and carrying out field tests to further improve the system.

Idaho and Washington have fully organized State Conservation Commissions. The Deans of Agriculture from these Land Grant Universities are members of their respective State Conservation Commissions.

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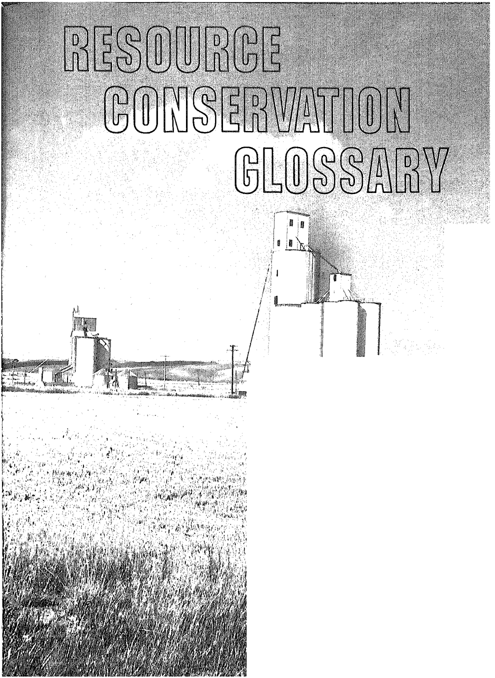
RESOURCE CONSERVATION GLOSSARY



Glossary

abatement: The method of reducing the degree or intensity of pollution, also the use of such a method.

absorption: The penetration of a substance into or through another, such as the dissolving of a soluble gas in a liquid.

acre-foot: The volume of water that will cover 1 acre to a depth of 1 foot.

aeration: 1. The process of being supplied or impregnated with air. 2. In waste treatment, the process used to foster biological and chemical purification. 3. In soils, the process by which air in the soil is replenished by air from the atmosphere. In a well-aerated soil, the soil air is similar in composition to the atmosphere above the soil. Poorly aerated soils usually contain a much higher percentage of carbon dioxide and a correspondingly lower percentage of oxygen. The rate of aeration depends largely on the volume and continuity of pores in the soil. The zone of aeration is the zone between the land surface and the water table.

algal bloom: Proliferation of living algae on the surface of lakes, streams, or ponds; stimulated by phosphate enrichment.

alkalinity: The quality or state of being alkaline; the concentration of OH negative ions.

alkali soil (obsolete): 1. A soil with a high degree of alkalinity (pH of 8.5 or higher) or with a high exchangeable sodium content (15 percent or more of the exchange capacity) or both. 2. A soil that contains sufficient alkali (sodium) to interfere with the growth of most crop plants.

annual cropping: A system of growing crops on the same land each year as opposed to a system which includes alternate years of crops with summerfallow.

annual precipitation: The amount of atmospheric condensation, in the form of snow, sleet, hail, rain, dew and fog, that falls on an area during a complete year.

annual sediment discharge: The quantity of sediment that is carried past any cross section of a stream during an annual period of time.

aquatic environment: An ecosystem in which both plants and animals are adapted to living completely under water—examples include lakes, streams and ponds.

aquifer: A geologic formation or structure that transmits water in sufficient quantity to supply the needs for a water development; usually saturated sands, gravel, fractures, and cavernous and vesicular rock. The term water-bearing is sometimes used synonymously with aquifer when a stratum furnishes water for a specific use.

chinook: A warm southwest wind that usually causes a warming trend during winter and spring months.

cobbly loam: Soil material consisting of loam and from 15 to 35 percent rock fragments and cobbles 3 to 10 inches in size.

conservation district: A public organization created under state enabling law as a special-purpose district to develop and carry out a program of soil, water, and related resource conservation use, and development within its boundaries; usually a subdivision of state government with a local governing body.

conservation practices: These practices are used to control erosion, conserve water, protect plants, or generally improve soil, water and plant resources.

contour: 1. An imaginary line on the surface of the earth connecting points of the same elevation. 2. A line drawn on a map connecting points of the same elevation.

cost-share programs: National farm programs developed whereby the farmer and the U.S. Government share together in the cost of applying conservation practices on the farmers' land.

crop residue: The portion of a plant or crop left in the field after harvest.

crop rotation: The growing of different crops in recurring succession on the same land.

crop sequence: The order in which crops occur in a cropping system or crop rotation.

cropping systems: A sequence of crops adapted to a particular climatic area. It may include grasses and legumes in rotation, fallow, cover crops and the cultural and management measures needed to successfully grow these crops. A "conservation cropping system" is one which protects the soil from erosion while growing these crops.

cultivation: To prepare land by tilling of the soil for the production of crops.

debris: The loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice, or floods.

debris dam: A barrier built across a stream channel to retain rock, sand, gravel, silt, or other material.

delivery ratio: The percentage of gross erosion which will be delivered to a downstream point of measurement.

discharge—weighted mean concentration: The theoretical sediment concentration if all the water and sediment passing a section during a time interval were mixed. Concentrations are expressed in milligrams per liter.

diversion: Individually designed channel and ridge across a hillside to protect an area from hillside runoff.

dryland farming: The practice of crop production in low rainfall areas without irrigation.

ecology: The study of interrelationships of organisms to one another and to their environment.

environment: The sum total of all the external conditions that may act upon an organism or community to influence its development or existence.

erodability: The ability or characteristics of a soil that causes it to wear or erode away by wind or water action.

erosion: The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. The following terms are used to describe different types of water erosion.

> **gully erosion:** The erosion process whereby water accumulates in narrow channels or depressions and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

natural erosion: Wearing away of the earth's surface by water, ice or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man.

rill erosion: An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils.

sheet erosion: The removal of a fairly uniform layer of soil from the land surface by runoff water.

stream channel erosion: Lateral recessions of the streambanks and/or degradation of the streams bottoms by stream flow action.

tillage erosion: The downhill movement of soil by use of tillage implements for crop production.

erosion rate: The amount or degree of wearing away of the land surface.

erosive: Refers to wind or water having sufficient velocity to cause erosion. Not to be confused with erodible as a quality of soil.

farm commodity programs: National farm programs developed to alleviate economic problems resulting from over-production.

fertilizer: Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth.

flood control: Methods or facilities for reducing flood flows.

fluvial sediment: Sediments deposited by stream action.

forb: A herbaceous plant which is not a grass, sedge, or rush.

forest: A plant association predominantly of trees and other woody vegetation.

forest management: Employing a number of practices such as planting, logging, fire and disease control in such a way that desired goals of use and conservation are achieved.

furrow slice: The soil in the plow layer that is over turned when a field is plowed.

geological uplift: Elevation or pushing up of an extensive part of the earth's surface relative to some other part.

glacial outwash: Cross-bedded gravel, sand, and silt deposited by water as it flowed from glacial ice.

glacial periods: Periods of alteration of the earth's surface through erosion and deposition by movement of glacial ice.

gradient: Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

grassed waterway: A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from cropland.

green manure crop: Any crop grown for the purpose of being turned under while green or soon after maturity for soil improvement.

groundwater: Phreatic water of subsurface water in the zone of saturation.

habitat: The environment in which the life needs of a plant or animal organism, population, or community are supplied.

herbicide: A chemical substance used for killing plants, especially weeds.

humus: That more or less stable fraction of the soil organic matter remaining after the major portion or added plant and animal residues have decomposed.

intermediate cuts: Harvesting a portion of the merchantable trees from an immature stand of trees.

intermittent streamflows: Streams which flow only during certain times when they receive water from springs or from precipitation.

lava flows: A stream of fluid or solidified fragmented lava which spews from an individual volcanic cone or from a fissure in relatively quiet fashion, with little or no explosive activity.

leaching: The removal from the soil in solution of the more soluble materials by percolating waters.

loess: Material transported and deposited by wind and consisting of predominantly silt-sized particles.

mean annual stream flow: Discharges observed and average over a water year (October through September).

minimum tillage: The least amount of tillage required to create the proper soil condition for seed germination and plant establishment.

natural resources: Naturally occurring resources needed by an organism, population, or ecosystem, which, by their increasing availability up to an optimal or sufficient level, allow an increasing rate of energy conversion.

natural revegetation: Natural re-establishment of plants; propagation of new plants over an area by natural processes.

no-tillage: A method of planting crops that involves no seedbed preparation other than opening the soil for the purpose of placing the seed at the intended depth.

noxious weeds: Plants that are undesirable because they conflict, restrict or otherwise cause problems under the present management objectives.

nutrients: 1. Elements, or compounds, essential as raw materials for organism growth and development, such as carbon, oxygen, nitrogen, phosphorus, etc. 2. The dissolved solids and gasses of the water of an area.

overwood removal: Removing the tallest trees as a weeding, sanitation or salvage operation.

particle size: The diameter, in millimeters, of suspended sediment or bed sediment. A classification recommended by the Sub-committee on Sediment Terminology of the American Geophysical Union defines a particle having a diameter of less than 0.004 mm (millimeter) as clay, between 0.004 and 0.062 mm as silt, and between 0.062 and 2.0 mm as sand.

parameter: A quantity or constant whose value varies with the circumstances of its' application.

pasture: An area devoted to the production of forage, introduced or native, and harvested by grazing.

percolation: The downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

permeability: Capacity for transmitting a fluid. It is measured by the rate at which a fluid of standard viscosity can move through material in a given interval of time under a given hydraulic gradient.

pesticide: Any chemical agent used for control of specific organisms; such as insecticides, herbicides, fungicides, etc.

planned grazing system: A system of grazing in which two or more grazing units are alternately rested in a planned sequence over a period of years. The resting period may be throughout the year or during the growing season of the key species.

pollution: The condition caused by the presence in the environment of substances of such character and in such quantities that the quality of the environment is impaired or rendered offensive to life.

pond: A water impoundment made by constructing a dam or embankment, or by excavating a pit or dugout.

poorly drained soils: Are wet for long periods, are light gray and generally mottled from the surface downward, and have limited uses for crop production.

proper grazing use: Grazing ranges and pastures in a manner that will maintain adequate cover for soil protection and maintain or improve the quality and quantity of desirable vegetation.

rangeland: Land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. Includes lands revegetated naturally or artificially to provide a forage cover that is managed like native vegetation. Rangelands include natural grassland, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.

range condition class: One of a series of arbitrary categories used to classify range condition, usually expressed as either excellent, good, fair, or poor.

river basin: The area drained by a river and its' branches.

runoff (hydraulics): That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, ground water runoff, or seepage.

scour: To abrade and wear away; used to describe the wearing away of terrace or diversion channels or stream beds.

sediment: Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

sediment discharge: The quantity of sediment that is carried past any cross section of a stream in a unit of time. Basically, sediment discharge is made up of two components, suspended-sediment discharge and bedload discharge.

sedimentary strata: Rock formed from sediment, such as conglomerate, sandstone, and shales, and formed of fragments of other rocks transported from their sources and deposited in water.

sediment yield: The sediment discharge from a unit of drainage area, generally expressed in tons per square mile.

shrub communities: Vegetation which is dominated by shrubby species.

silt: 1. A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter. 2. A class of soil texture.

silt loam: A soil textural class containing a large amount of silt and small quantities of sand and clay. See soil texture.

silty clay: A soil textural class containing a relatively large amount of silt and clay and a small amount of sand.

silvicultural: The cultivation and care of trees in a forest.

soil association: 1. A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways. Sometimes called "natural land type." 2. A mapping unit used on reconnaissance or generalized soil maps in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

soil moisture: Water retained in the soil for use by plants.

soil organic matter: The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil sample passed through a 2-millimeter sieve.

soil productivity: The inherent capacity of a soil to produce a specified crop or sequence of crops in its' normal environment.

soil profile: A vertical section of the soil from the surface through all its horizons, including C horizons.

soil slip: Areas of varying size that have become saturated, and due to excessive steepness, have slipped downhill—a small land-slide.

soil structure: The combination or arrangement of primary soil particles into secondary particles, units, or peds. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

soil texture: The relative proportions of the various soil separates in a soil. The textural classes may be modified by the addition of suitable adjectives when coarse fragments are present in substantial amounts, for example, gravelly silt loam.

spawning beds: Areas within a stream, lake or pond, usually containing gravel, upon or in which fish deposit eggs to complete their embryonic development.

stagnated thicket: Very dense stands of trees, generally five to twenty-five feet high, where no trees are able to express dominance.

stratification: The process of arrangement or composition in strata or layers.

stream reaches: A length of stream channel selected for use in hydraulic or other computations.

stripcropping: Growing crops in a systematic arrangement of strips or bands which serve as barriers to wind and water erosion.

structural treatments: A group of practices which control water after it has become runoff, such as terraces, waterways, drop structures, etc.

stubble mulch: The stubble of crops or crop residues left esentially in place on the land as a surface cover during fallow and the growing of a succeeding crop.

stumpage value: The monetary value of the tree or timber stand before it is cut.

subwatershed: A watershed subdivision of unspecified size that forms a convenient natural unit. See watershed.

summerfallow: The tillage of uncropped land during the summer in order to control weeds and store moisture in the soil for the growth of a later crop.

super-saturated: Free water or water in excess of what the soil is capable of holding.

supplimental irrigation: Water supplied to a crop when either rainfall or the principal irrigation supply are inadequate to produce a crop.

suspended sediment: The sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

sustained yield: Managing a forest for continued production, where production is equal to the yield.

terrace system: A series of terraces occupying a slope and discharging runoff into one or more outlet channels.

tillage: The operation of implements through the soil to prepare seedbeds and root beds.

tillage erosion: The downhill movement of surface soil, caused by tillage equipment when using them on sloping land.

topography: The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface.

topsoil: 1. Earthy material used as top-dressing for house lots, grounds for large buildings, gardens, road cuts, or similar areas. It has favorable characteristics for production of desired kinds of vegetation or can be made favorable. 2. The surface plow layer of a soil; also called surface soil. 3. The original or present dark-colored upper soil that ranges from a mere fraction of an

inch to two or three feet thick on different kinds of soil. 4. The original or present A horizon, varying widely among different kinds of soil. Applied to soils in the field, the term has no precise meaning unless defined as to depth or productivity in relation to a specific kind of soil.

toxicity: Quality, state, or degree of the harmful effect resulting from alteration of an environment factor.

tributary: Secondary or branch of a stream, drain, or other channel that contributes flow to the primary or main channel.

understory vegetation: The vegetation, generally under fifteen feet in height, that grows beneath the tree canopy.

universal soil loss equation: An equation used to design water erosion control systems: A = RKLSPC wherein A is average annual soil loss in tons per acre per year; R is the rainfall factor; K is the soil erodibility factor; L is the length of slope; S is the percent slope; P is the conservation practice factor; and C is the cropping and management factor. (T = soil loss tolerance value that has been assigned each soil, expressed in tons per acre per year).

upland game bird: Ground dwelling, chicken-like birds that are not necessarily dependent on wetlands for their survival—e.g. quail, pheasant, grouse, partridge.

vegetation cover: The soil surface protection against rain drop or runoff erosion or wind erosion by living plant materials such as grasses, legumes, cereal grains or other growing crops.

velocities: As referred to here in the study, the speed at which water flows.

volcanic activity: Pertaining to the phenomena of volcanic eruption, the explosive or quiet emission of lava or volcanic gasses at the earth's surface.

water holding capacity: The amount of water that a given soil can hold.

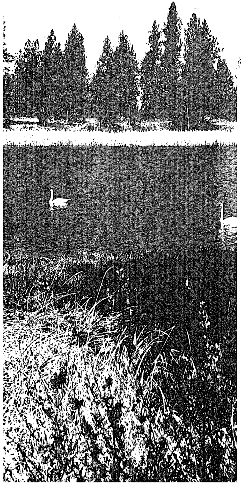
watershed area: All land and water within the confines of a drainage divide or a water problem area consisting in whole or in part of land needing drainage or irrigation.

wetland: Land where water on or near the soil surface is the dominant factor determining the types of plant and animal communities living in the soil or on its' surface.

wildlife: Undomesticated vertebrate animals, except fish, considered collectively.

windbreak: 1. A living barrier of trees or combination of trees and shrubs located adjacent to farm or ranch headquarters and designed to protect the area from cold or hot winds and drifting snow. Also headquarters and livestock windbreaks.

APPENDIX



Appendix

Study Methodology

Literature Search[1]

With two major agricultural universities located within the basin and associated research facilities connected with these universities, extensive data on the problems of the area and their effects are available. In this study, over 300 reference sources, most of which originated at the universities, were found about the Palouse and related erosion problems. Data from these sources has been used extensively in this study to improve its usefulness, scope, and accuracy. Available data was also used in establishing study direction and intensity.

Evaluation Area Selection —Cropland

In order to achive study objectives, a process of utilizing evaluation areas as a base for the study was used. The study areas used were selected following discussions with cooperative study leaders, Washington State University and University of Idaho staff members, and personnel of the Agricultural Research Service and the Cooperative Extension service with extensive experience in the basin. Evaluation areas were selected to meet the following criteria:

1. represent the soils of the basin;
2. adequately represent rainfall zones of the basin;
3. be large and numerous enough to provide sound and meaningful data;
4. lend themselves to soil loss and economic analysis;
5. be within the range of stream monitoring stations;
6. be representative of major soil erosion problem areas.

[1]See Bibliography Section

It was decided to select one evaluation area for each of the major soil association areas in the basin. Areas of approximately 1,400 acres were used. The areas used had previously been selected by SCS soil scientist Herman Gentry as representative areas of the major soil associations. Each area is approximately 1.3 miles wide by 1.7 miles long. Land ownership and operation of the areas varied from as few as three to as many as seven different farmers. Evaluation area boundaries do not necessarily follow section lines or ownership boundaries. (See Figure 16) Fifteen areas were evaluated.

Field sheets used in the study include 8"/mile scale aerial photographs, soils survey maps, and contour maps of each evaluation area.

Each farmer in each evaluation area was interviewed.[1] Data obtained from the farmers included cropping system, crop yields, machinery usage and farm operation inputs. Fifty farmers were interviewed.

Field data for use in universal soil loss equation computations was collected on each evaluation area. Because of complex topography in the basin (see Figure 16, topographic diagram) and as influenced by the amount of cropland in the evaluation area, intensity of field study was varied (the more complex topography and areas with high percentages of cropland received most intensive field analysis).

[1]Exception: One farmer refused interview, and three could not be contacted.

The soil loss equation is expressed as: A = RKLSCP.

A = average annual soil loss in tons/acre/year.
R = rainfall and runoff factor.
K = soil erodibility factor.
LS = length and steepness of slope combination.
C = cropping management factor.
P = erosion control practice factor.

All factors except the LS factor were available from various published sources including Sheet and Rill Erosion Control Guide, State of Washington, Whitman County Soil Survey and soil survey maps of the evaluation areas. Representative slopes in each evaluation area were selected and measured for use in determination of LS (length and steepness) values. An average of eight slopes were measured in each evaluation area. Because of slope irregularity and/or soil differentiation, all slopes were segmented and soil loss analysis was made for each segment.

Data from farm and field was assembled for use in two major computer analysis programs.

U.S.L.E. Computer Analysis—Cropland

Computer analysis of soil loss rates was conducted for each evaluation area in four programs. The first program evaluated each slope and each slope segment for each farm in each evaluation area. Soil loss rates were projected for 13 cropping-management systems (C values) and six conservation practices (P values). Analysis was made for each slope with and without terrace installations. (See Figure 16 and Table 36). Analysis was also conducted to study effects of retiring Class IVe and VIe land from cultivation.

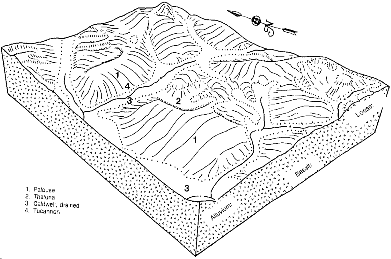


Figure A-1 Major soils in the Palouse-Athena association and their relationship to the landscape in the valley of Willow and Pine Creeks. Location: NW cor. of block diagram is 2800 feet east of NE cor. of Sec. 9, T19N, R45E.

Table 35. Crop Rotations and Conservation Practices Items Evaluated—C and P Values

		C Value
C1	Annuel Winter Wheat, fall plow, fall disc 500-1,000 lbs. residue	.24
C2	Annual Winter Wheat, fall chisel, fall disc 2,500 lbs. residue	.08
C3	Seeding out Class VI only	.01
C4	Seeding out Class IV and VI	.01
C5	Winter Wheat—Peas, chisel wheat, chisel peas	.18
C6	Winter Wheat—Peas, fall plow wheat, any tillage peas	.48
C7	Winter Wheat—Spring Grain—Peas fall chisel all crops	.13
C8	W—P—W—P—3 to 5 years, Alfalfa and Grass chisel all crops, plow green manure	.09
C9	No till Winter Wheat	.03
C10	Wheat-Fallow; No Stubble Mulch 700 lbs. residue	.37
C11	Wheat-Fellow; Stubble Mulch 2,000 lbs. residue	.13
C12	Wheat-Barley-Fallow, no stubble mulch Moldboard plow	.27
C13	Wheat-Barley-Fallow, stubble mulch fallow	.15

Table 36. Soil Loss Summary Table Per Evaluation Area Palouse-Athena Soil Association

Evaluation: G-8
Average Slope: 14%
Date: 2/15/77

N	Average P (N) Value	Annual Winter	Wheat	Winter Wheat	& Peas	Wheat, Barley And Peas	Wheat-Peas And Alfalfa	No Till
		C = 0.24	C = 0.08	C = 0.18	C = 0.48	C = 0.26	C = 0.09	C = 0.03
				WITHOUT TERRACES AND WITHOUT GRASS				
1	0.85	7.82	2.60	5.86	15.64	8.47	2.92	0.97
2	1.00	8.71	2.89	6.53	17.43	9.44	3.26	1.08
3	0.83	7.64	2.54	5.73	15.29	8.28	2.86	0.94
4	0.71	6.95	2.31	5.21	13.91	7.53	2.60	0.86
5	0.54	5.52	1.83	4.14	11.06	5.99	2.06	0.68
6	0.36	3.73	1.24	2.79	7.47	4.04	1.39	0.45
				WITHOUT TERRACES AND WITH GRASS				
1	0.85	6.07	2.07	4.57	12.09	6.57	2.31	0.81
2	1.00	6.97	2.37	5.24	13.88	7.54	2.65	0.93
3	0.83	5.90	2.01	4.44	11.74	6.38	2.25	0.79
4	0.71	5.21	1.78	3.92	10.35	5.64	1.99	0.71
5	0.54	3.92	1.35	2.95	7.79	4.25	1.51	0.54
6	0.36	2.63	0.90	1.98	5.23	2.85	1.01	0.36
				WITH TERRACES AND WITHOUT GRASS				
1	0.65	7.21	2.40	5.40	14.44	7.81	2.70	0.89
2	1.00	7.97	2.65	5.97	15.95	8.63	2.98	0.98
3	0.83	7.05	2.34	5.28	14.11	7.64	2.64	0.87
4	0.71	6.48	2.15	4.86	12.98	7.02	2.42	0.80
5	0.54	5.18	1.72	3.88	10.38	5.61	1.93	0.63
6	0.36	3.50	1.16	2.62	7.00	3.78	1.30	0.43
				WITH TERRACES AND WITH GRASS				
1	0.85	5.47	1.87	4.12	10.88	5.92	2.09	0.74
2	1.00	6.23	2.12	4.69	12.39	6.74	2.37	0.83
3	0.83	5.31	1.81	4.00	10.56	5.75	2.03	0.72
4	0.71	4.74	1.62	3.57	9.42	5.13	1.82	0.65
5	0.54	3.58	1.23	2.69	7.03	3.87	1.37	0.49
6	0.36	2.40	0.82	1.81	4.76	2.59	0.92	0.33

Program two provided summary data by slope, program three provided summary data by farm, and program four provided summary data by evaluation area. Major data output is predicted soil loss rate by slope, farm, and evaluation area.

Economic Computer Analysis

Data collected during farm interviews was consolidated into three major rainfall zones for economic analysis. This consolidation was done to reduce computer costs and considered desirable because of small differences in farming systems in the three major rainfall zones. The zones used were under 15" annual rainfall, 15"-18" annual rainfall, and 18+" annual rainfall.

Economic analysis was performed for all cropping-management systems, conservation practices and use of terrace systems as performed in the USLE computer programs. Data output includes net returns in fuel use $/acre, and gallons/acre, and fertilizer use in $/acre for each alternative land management system and potential supporting conservation practice.

Linear Program—USLE and Economics

A linear program was performed by ESCS, using USLE and economics computing program output to provide comparative data for alternative land management systems on maximum feasible net income, minimum feasible soil erosion, best technical (minimum soil loss plus best feasible economics), restricted fuel availability and restricted wheat price constraint programs.

Linear programming was the technique used in analyzing the various land management systems in the Palouse. This technique is mathematical in nature and can be defined as a method of maximizing, or minimizing, a linear function. Such a function consists of a number of variables subject to a number of restraints which are stated in the form of linear inequalities.

As an example, let us assume that a farm produces two products, corn for silage (X_1) and barley (X_2) which can be sold at prices of $3.64 and $1.00 per cwt. respectively. Therefore Px_1 = $3.64, and Px_2 = $1.00. Let it also be assumed that the farm has available 600 acres of land (a), 88,000 pounds of fertilizer (b), and 22,000 acre-inches of water (c).

It is also assumed that one unit of X_1 requires 0.0033 units of a, 0.4500 units of b and 0.1500 units of c. The problem facing the farmer is one of producing the maximum amount of revenue from the sale of X_1 and X_2, consistent with the given prices of the crops and within the constraints imposed by the existing supplies of inputs. We assume further that the farmer cannot produce negative amounts of the two crops, X_1 and X_2, and that he may not produce any amount at all of one of the crops—i.e., $X_1 > 0$ and $X_2 > 0$. Finally, the farmer knows that barley, X_2, requires 0.0417 units of a, 6.25 units of b, and 1.4583 units of c.

It is now possible to write the mathematical equations which emphasize the constraints in terms of inputs subject to which X_1 and X_2 must be produced. These are as follows:

$$0.0033(X_1) + 0.0417(X_2) = 600$$
$$0.4500(X_1) + 6.2500(X_2) = 88{,}000$$
$$0.1500(X_1) + 1.4583(X_2) = 22{,}000$$

The combinations of linear functions and the number of variables necessary to analyze the alternative land management systems in the Palouse resulted in a linear programming problem more complicated than the example shown above. First of all, three distinct precipitation zones were involved: less than 15-inches, 15 to 18 inches, and greater than 18-inches. There were 13 distinct cropping patterns. Each cropping pattern supplied erosion costs, total production costs, total profit, yield, fuel requirements, fertilizer requirements, gross receipts, and the tons of erosion reduced by each land management system. In addition, there was a possibility of 53 land management systems.

The land management systems were separated into three major zones according to the amount of precipitation in each zone. Precipitation effects the combinations of crops grown, the types of tillage systems and equipment used, and the resulting soil loss and sediment delivery rates from each zone. The soil loss for each management system was computed using the Universal Soil Loss Equation and the data provided by the Soil Conservation Service.

Erosion control measures in the Palouse River Basin can be either nonstructural or structural, or a combination of the two. Nonstructural measures include improved tillage

systems, changes in cropping patterns or combinations thereof. Structural measures include the use of terracing, stripcropping and similar measures. The management systems within the Basin consist of measures that control erosion by the application of combinations of the following principles:

1. Install conservation practices as required because of topography, soils and vegetative cover to reduce erosion.
2. Retain and protect suitable existing vegetation wherever possible to retard runoff and erosion.
3. Provided structural measures to accomodate increased runoff resulting from changed soil and surface conditions.
4. Install permanent vegetative and structural erosion control to stabilize critical erosion areas.
5. Maintain vegetative and structural improvements to insure their effectiveness.
6. Adjust land use to assure that flatter, less erosive lands are used for cultivated crops and steeper Class IVe and VIe lands are used for permanent grass crops.

The above principles were incorporated into each rainfall zone by cropping pattern and management system. Each combination examined the changes in agricultural production resulting from the regulation of erosion control rates.

Evaluation Areas—Rangeland

USLE projections for rangeland were performed in a manner very similar to that used on cropland. The three evaluation areas with major acreages of rangeland were evaluated. Soil loss predictions for rangeland were prepared. Economic analysis was not performed for rangeland areas because of good budget data already available and the low soil loss rates projected for rangeland which obviated the need for consideration of alternative management systems for this land.

Evaluation Area—Forest Land

Small areas of forest land are found in only three evaluation areas of the Palouse Basin in Washington. Soil loss rate predictions have been prepared for these areas. The U.S. Forest Service has performed extensive analysis of soil loss and sediment delivery on forested portions of the basin in Idaho.

Sediment yield can be defined as the effluent from a Soil Processing System. The "System" is a diffuse natural process known as soil erosion. This System is distributed in time and space, and can be accelerated or decelerated by a multitude of factors, including the activities of man. The effluent from the Soil Processing System is a heterogeneous mixture of mineral and organic matter ranging from small to large particles, with a variety of natural or acquired chemical and biological properties.

There has been concern in the United States for sediment yield to streams and reservoirs for over 100 years. Only recently, however, have we begun to appreciate the water quality implications of sediment as a pollutant in the same context as effluent from industrial, sewage, and other point sources of pollution entering water bodies. Likewise, we have become aware of the ability of sediment to transport other pollutants. For instance, persistent chlorinated hydrocarbons such as Dieldrin have a low solubility in water, but are strongly absorbed by soil particles.

Phosphorus applied as a fertilizer is also strongly absorbed onto soil particles and moves to streams and other water bodies primarily attached to sediment from erosion. Significant nitrogen-sediment relationships have been illustrated by the Agriculture Research Service in southwestern Iowa (1973).

The procedures used for the forest land portion of the Palouse first involved an estimate of the gross erosion. This was accomplished by constructing a mosaic of 1 inch = mile aerial photography. The landforms were mapped using standard procedures. They were further adjusted using existing slope, vegetation, soil disturbance, climatic, and geologic types; and grouped into 10 distinct erosion producing units.

Rates of erosion were established using actual plot data as a basis to adjust research findings and output from the universal soil loss equation. Channel erosion was based on photo comparison and field survey of stream channel morphology. The U.S. Forest Service, Region 1, procedure for stream channel stability determination was used and correlated with regression curves for channel erosion versus channel stability by Hydrologist, C. Benoit. Erosion rates were adjusted to long-term climatic conditions, 1960-1975 base. These erosion rates

range from .06 to 3.95 tons/acre/year. A weighted average of 65.5 tons per mile was used for the 139 miles of stream channel erosion to produce a gross erosion of 70,594.5 tons. Helli Smith bedload sample data indicate that approximately 1/2 of the stream channel erosion is bedload and 1/2 is suspended load.

Fluvial sediment was determined by sampling stream flow over time using a DH-48 and DH-59 depth integrated sediment samplers according to U.S. Geological Survey recommended techniques. Again, a Helli Smith was used for bedload. This data was compared with stream flow, producing a sediment-discharge regression. This regression had a confidence R_2 value of .92. Mean annual runoff for each basin was estimated using Idaho runoff isohyetal maps developed by Dr. Marvin Rosa, U.S. Agriculture Research Service. The timing of runoff was based on the U. S. Geological Survey Gauging Station (13345) data for the Palouse. These synthesized hydrographs were applied against the regression (sediment discharge) to develop mean annual weighted gross sediment delivery of 17,957.6 tons from all sources. This results in an overall sediment delivery ratio of .25; that is, 1 out of every 4 tons of erosion leaves the forest land as fluvial sediment.

These procedures are further documented in Agriculture Research Service publication S-40 dated June 1975 and other references cited in Hydrologist, C. Benoit's report dated November 1976 for the Palouse, Chapter VII of this report.

Evaluation—Wildlife Habitat

The loss of wildlife habitat has been frequently noted, but seldom measured or the results quantified. Therefore, an attempt was made to quantify and express numerically the value of wildlife habitat on the same sample plots selected for evaluation in other portions of this study. The evaluation of wildlife habitat was based on three assumptions:

(1) The abundance and distribution of water and various vegetative types directly affects the total number of species as well as the total wildlife population of any given area of land; (2) the value of any habitat or vegetative type is modified by the management of the habitat; e.g., types of tillage operations, grazing intensity, burning, use of herbicides and insecticides, etc.; and (3) when values for abundance, distribution and management are at optimum levels, the wildlife populations will also occur at optimum levels. Optimum being the greatest diversity and density of wildlife attainable for a given area.

A habitat evaluation technique proposed by Thomas (1974) and later modified by Applegate (1974) was adopted for use. The "Thomas Technique" predicts the relative value of wildlife habitat based on the abundance, distribution and management of defined vegetative types. The technique was modified for use in the Palouse by defining vegetative types of importance to wildlife in the Palouse area—e.g., herbaceous vegetation, woody vegetation, and cropland; by expressing the importance of wildlife drinking water; and by developing vegetation management values for management systems commonly used in the Palouse area. The validity of the Thomas Technique for predicting habitat value was field tested by Oakerman (1976). He found significant positive correlations between the predicted habitat values and wildlife diversity (r = .95) and predicted habitat values and wildlife density (r = .82).

The evolution of habitat value is performed by placing 20 random points on a photo-mosaic of the study area. The distance from each point to herbaceous, woody or cropland vegetation is measured on the photo and field checked to minimize errors in differentiating the three vegetative types from the photos. The mean distance (x) to each vegetative type is then calculated. During the field check, the management of each of three vegetative types is noted, as well as the distribution of water on the plot.

The mean distance (x), management and water distribution are then each assigned a relative value between one-tenth (0.1) and one (1.0); one-tenth representing little value for wildlife and one representing an optimum value for wildlife (See Tables A,B). The relative values are then "plugged into" the formula to arrive at an overall habitat for each plot.

An example of the habitat evaluation technique is:

1,000 acres of land, of which (a) 750 acres is cropland—a wheat-fallow rotation, crop residues incorporated by chiseling x distance .5, water available on the average of 1/2 mile; (b) 200 acres is herbaceous vegetation—heavily grazed pasture, x distance .3, water available on the average is less than 1/2 mile; (c) 50 acres is woody vegetation, an open windbreak with a heavy understory of grass that is ungrazed, overstory damaged by herbicide drift from ad-

joining cropland, x distance 6.5, water available on the average 1/2 mile. This is summarized as follows:

(1) Vegetation type	(2) Acreage	(3) Abundance	(4) Management	(5) Water Availability	Acre Value (2)x(3)x(4)x(5)
Crop	750	.6	.5	1	225.0
Herbaceous	200	1.0	.3	1	60.0
Woody	50	.4	.4	1	8.0
	1,000				293.0 acres

Habitat Value 293/1000 = 0.29

This value (0.29) means that the habitat requirements of wildlife found on the entire plot area could be satisfied, on 29% (293 acres) of that area, if conditions on the 293 acres were optimum for wildlife. If, for example, the abundance and distribution of crop, herbaceous and woody vegetation were adjusted to provide optimum conditions for wildlife (see Table A), with no change in management, all of the values in column 3 would become 1.0. This would result in a **habitat value** of 0.43—or 430 acres. On the other hand, if management was improved to a value of 1.0 for all vegetative types with no change in the abundance or distribution of vegetative types, the result would be a **habitat value** of 0.67—or 670 acres.

Table 37. Vegetation Abundance and Habitat Value for the Palouse River Basin

Percent Abundence	0%	5%	10%	15%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Cropland	0	.4	.6	.7	.9	1.0	1.0	1.0	.9	.7	.5	.2	.1
Herbaceous	0	.1	.4	.8	1.0	1.0	1.0	.9	.8	.7	.6	.5	.3
Woody	0	.4	.5	.7	.9	1.0	1.0	.9	.8	.8	.7	.6	.4

Acre Value (Abundance and Distribution)[1]

X Distance In 100 feet	0-0.1	0.2-0.4	0.6-0.8	1.0-1.2	1.4-1.8	1.8-2.0	2.5-3.0	4.0-5.0	8.0-7.0	6.0-0.0	10.0	11.0	12.0	13.0
Cropland	.1-.5	.8-.7	.8-1.0	1.0-1.0	1.0-1.0	1.0-1.0	1.0-.9	.7-.6	.6-.5	.4-.4	.3	.1	.1	.1
Herbaceous	.3-.6	.7-.8	.8-.9	.9-.9	.9-1.0	1.0-1.0	1.0-1.0	.8-.8	.5-.3	.1-.1	.1	.1	.1	.1
Woody	.4-.8	.7-.8	.9-.9	1.0-1.0	1.0-1.0	1.0-1.0	1.0-.9	.7-.5	.5-.4	.4-.3	.3	.1	.1	.1

[1]Values for abundance and distribution are combined as suggested by Applegate (1974).

Table 38. Habitat Management Values

Grain and Seed Crops	Value
a. Grain and seed crops managed specifically for wildlife—a portion of the crop left unharvested; no till system or residue not disturbed in fall; no spring plowing; no grazing.	1.0
b. Same as "a", except not specifically managed for wildlife.	0.8
c. Crop residue chiseled in fall-spring tillage does not include plowing.	0.6
d. Crop residue fall disked or chopped—no spring plowing.	0.5
e. Crop residue fall plowed.	0.3
(No value to exceed 1.0 or less than 0.1)	
Deduct 0.1 for fallow in rotation 0.2 for peas or lentils in rotation 0.1 for moderate grazing of stubble 0.2 for burning of crop residue **Add** 0.1 or 0.2 for stripcropping (depending on value of rotation to wildlife).	

Table 38. Habitat Management Values (Continued)

Woody Vegetation	Value
a. A stand of woody vegetation that contains a combination of species, successional stages, and stocking levels, which is specifically managed for wildlife.	1.0
b. Same as "a", except not specifically managed for wildlife.	0.8
c. An even-age stand of moderate stocking with a heavy understory.	0.6
d. An even-age mature stand of moderate to heavy stocking with light understory.	0.4
e. A decadent or overstocked even-aged stand that has no understory.	0.2
(No value greater than 1.0 or less than .1)	
Deduct .1 for stands where understory is grazed lightly	
.2 for stands where shurbby vegetation is moderately hedged	
.3 for stands where shrubby vegetation is severely hedged and patches of bare soil exist	
.2 for stands where the overstory has been damaged by herbicides	
.2 for stands where understory has been removed by fire	
.2 for stands where cultivation is done up to the edge of the stand	
.2 for stands where cultivation has removed the understory	
Add .2 for stands where fruit from planted trees is not harvested	

Table 38. Habitat management Values (Continued)

Herbaceous Vegetation	Value
a. A stand composed of grasses, forbs, and legumes specifically managed for wildlife.	1.0
b. Same as "a", except not managed specifically for wildlife.	0.8
c. Light to moderate grazing that does not significantly reduce the species composition or vigor of the vegetation, cover not drastically reduced, utilization patchy.	0.7
d. Proper use of the forage obtained under a grazing system, species composition reduced to those species that can withstand grazing, all types of hay fields are included in this category, cover reduced to 4-6" tall at the end of the grazing season.	0.6
e. Intensive use of the forage resource, species composition reduced to those plants that are less palatable or can withstand heavy grazing, cover reduced to 2-4" at the end of the grazing season, soil erosion not evident.	0.3
f. Overuse of the forage resource, species composition reduced to those annual and invading species that can withstand the heavy grazing, cover reduced to 1-2" tall at the end of the grazing season, soil erosion evident.	0.2
(No value to exceed 1.0 or less than .1)	
Deduct .1 for stands where understory is grazed lightly	
.2 for stands where shrubby vegetation is moderately hedged	
.2 for grazing hay aftermath	
.1 for spring burning	
.2 for fall burning	
.3 for fall burning of hay aftermath	
Add .1-.2 for deferment grazing systems (depending on the level of utilization and the value of the system for wildlife)	

Table 39. Water Availability Values

Water Availability	Value
a. Perennial water source distributed over an area so that the average distance to water is less than 1/8 of a mile.	1.0
b. Water sources distributed over an area so that the average distance to water is greater than 1/8 of a mile but less than 1/4 of a mile.	0.8
c. Water sources distributed over an area so that the average distance to water is greater than 1/4 of a mile but less than 1/2 of a mile.	0.6
d. Water sources distributed over an area so that the average distance to water is greater than 1/2 mile but less than 3/4 of a mile.	0.4
e. Water sources distributed over an area so that the average distance to water is greater than 3/4 of a mile but less than 1 mile.	0.2
f. Water sources distributed over an area so that the average distance to water is greater than one mile.	0.1
(No value greater than 1.0 or less than .1)	
Deduct .2 if only water sources are at an occupied farmstead .2 if permanent cover (woody and herbaceous) does not adjoin the water source .2 if cover adjoining the water source is reduced to under 1 ft. by grazing, cultivation, or mowing Add .1 if water sources are developed to increase accessibility or safety to wildlife (i.e., floating blocks or access and escape ramps installed on troughs and tanks)	

Under present management systems, the **habitat values** and **equivalent acreage** for thirteen 1200 acre study plots are presented below:

Table 40. Habitat Values

Plot No.	Habitat Value	Equivalent Acreage
1	0.022	26
2	0.024	30
4	0.176	211
5	0.012	14
6	0.320	384
7	0.233	280
8	0.022	27
9	0.004	5
10	0.023	28
11	0.008	10
12	0.443	532
13	0.286	343
15	0.021	26

From these data, it can be concluded that many plots, under existing conditions, are of very little value to wildlife. As much wildlife could be produced on **5 acres**, under optimum conditions, as is presently being produced on the **1200 acres** in **Plot 9**. As much wildlife could be produced on **14 acres** and 10 acres, under optimum conditions, as is presently being produced on 1200 acres each in **Plots** 5 and 11 respectively.

Applegate, Jonas E.—**Modification of SCS Techniques for Predicting Wildlife Habitat Value**, Mimeographed Report of Rutgers University, 1974

Oakerman, Grover—**Wildlife Evaluation In The Palouse River Basin**, Mimeographed Report of the Washington Game Department, 1976

Thomas, Carl H.—**Predicting Land Use Effects on Wildlife Habitat**, Mimeographed Report of the Soil Conservation Service, 1974

Habitat Values were recalculated for each of the thirteen study plots based on land management alternatives proposed to reduce soil erosion to acceptable levels. The three broad soil conservation alternatives evaluated were:

Alternative I. Remove crops from steep, erosive Class IV and Class VI land. Place this acreage in permanent herbaceous (grass/ legume) cover. Assume that the present level of management, with regard to tillage operations, grazing, burning, pesticide use, etc.—will remain the same as it is at present.

Plot No.	Habitat Value	Equivalent Acreage
1	0.150	180
2	0.059	71
4	0.348	418
5	0.082	98
6	0.363	436
7	0.246	295
8	0.027	33
9	0.032	38
10	0.167	201
11	0.109	131
12	0.443	532
13	0.074	89
15	0.158	189

A comparison of these habitat values and equivalent acreages with those under existing conditions (Table 40), indicates a significant improvement for wildlife.

Alternative II. Improve the management of cropland, herbaceous and woody vegetation. Conservation practices applied to prevent excess soil loss and deterioration of water quality—e.g., minimum tillage, proper grazing use, no plowing, no burning, contour farming, stripcropping, etc. The abundance and distribution of cropland, woody and herbaceous vegetation are assumed to remain the same as they are at present.

Plot No.	Habitat Value	Equivalent Acreage
1	0.030	36
2	0.036	43
4	0.201	241
5	0.031	38
6	0.355	426
[illegible]	0.280	335
[illegible]	[illegible]	80
[illegible]	[illegible]	7
[illegible]	[illegible]	143
[illegible]	[illegible]	51
[illegible]	[illegible]	646
[illegible]	[illegible]	343
[illegible]	0.031	38

The application of soil and water conservation practices improves the quality of habitat over existing conditions. However, note that the improvement is not as significant as those resulting from Alternative I.

Alternative III. The third alternative evaluated is a combination of Alternatives I and II, above. This alternative assumes that Class IV and Class VI land is converted to permanent herbaceous cover and extensive soil and water conservation measures are applied to all lands.

Plot No.	Habitat Value	Equivalent Acreage
1	0.155	186
2	0.089	106
4	0.385	463
5	0.113	135
6	0.396	475
7	0.295	454
8	0.076	92
9	0.041	50
10	0.270	325
11	0.139	166
12	0.538	646
13	0.444	533
15	0.205	245

This alternative obviously provides the best habitat conditions for wildlife, as well as providing protection of soil and water resources.

The equivalent acreage of value to wildlife are presented below for comparison. It is interesting to note that the most significant improvement of wildlife habitat occurs as a result creating more permanent cover as shown in Alternative I. These data support very strongly, the contention that the limited amount of permanent vegetation in the Palouse, is the single most limiting factor for wildlife populations.

Plot No.	Existing Conditions	Alternative I	Alternative II	Alternative III
1	26	180	36	186
2	30	71	43	106
4	211	418	241	463
5	14	98	38	135
6	384	436	426	475
7	280	295	335	454
8	27	33	80	92
9	5	38	7	50
10	28	201	143	325
11	10	131	51	166
12	532	532	646	646
13	343	343	343	343
15	26	189	38	245

Evaluation—Sediment Delivery Rates

Data from sediment pond studies on 10 ponds in and near the Palouse Basin has been used to project sediment delivery ratios. Watersheds above the 10 ponds studied vary from 120-2,560 acres, with a mean of approximately 300 acres. Additional sediment delivery data from extensive sediment delivery studies on the Missouri Flat Creek watershed near Pullman has also been used.

Data Expansion Procedures

Data from evaluation areas includes estimated existing soil loss rates and project soil loss rates with alternative land management systems in tons/ acre/year. This data has been expanded to provide:

a. projected soil loss rates by soil association/year;
b. projected soil loss rates by land capability class/year;
c. projected soil loss rates by subwatershed/year;
d. projected soil loss rates for the Palouse River Basin/year;
e. projected soil loss rates by rainfall zone.

Economic data expansion is minimal except for purposes of comparing alternative land management systems. Census data has been used for overall economic analysis of the basin.

Sediment yield studies have been expanded to show projected sediment yields by subwatershed and for the Palouse Basin.